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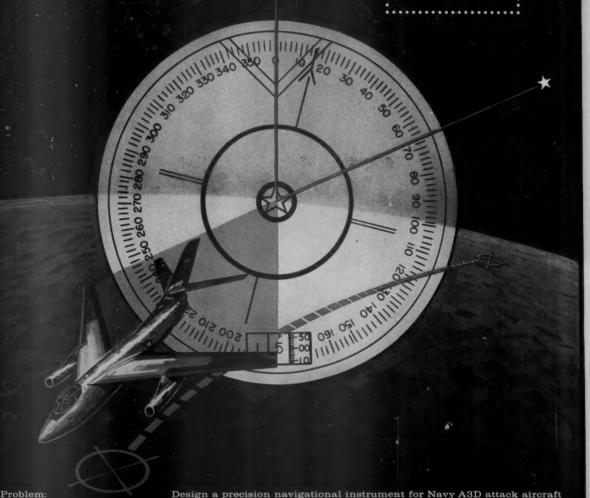
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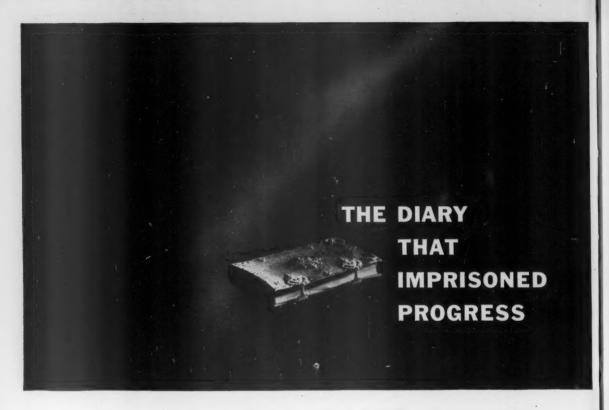
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Nearly two centuries ago, Karl Gauss, "Prince of Mathematicians," kept a diary which was destined to become one of the most significant documents in the history of mathematics.

In his diary Gauss jotted down the results of elaborate calculations that had led him to fundamental discoveries in mathematics. But he never published these discoveries, and many of them remained undisclosed during his lifetime.

It wasn't until almost 50 years after Gauss's death that his diary was found and published. Much time and talent, meanwhile, had been spent in duplicating Gauss's efforts. Mathematical progress had been needlessly slowed.

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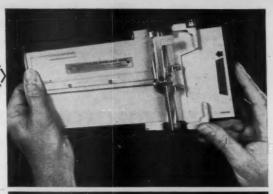
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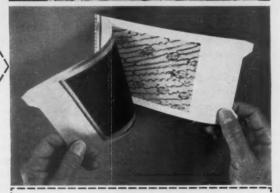
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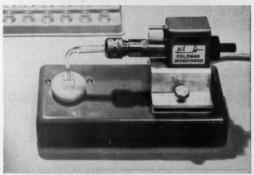
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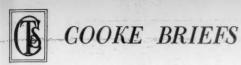
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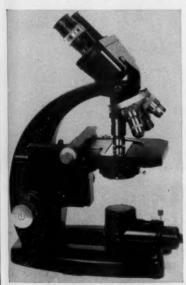
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Instruments and Applications

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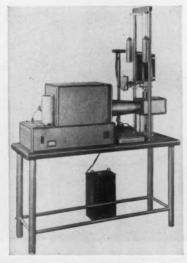
It is inevitable that conventional achromatic objectives have a certain amount of field curvature, if the best central definition is to be obtained. There is, however, a need for highpower dry objectives with flat fields. especially in the more routine laboratory uses of the microscope, and many makers compute their 40X objectives to give a flatter field while sacrificing something in resolution. In these past few years some elaborate designs have given flat fields without this compromise, but these objectives have not been generally adopted because of the very high cost involved.



A new basic approach to this design problem has been taken by Cooke resulting in the development of a new 40X achromatic objective. The Microplan 40 gives an extremely flat field of view, retains the maximum definition of the best N.A. 0.65 conventional achromatic objectives, and costs only slightly more. Because of tube length considerations the objective is most suitably used with the Cooke M15 Biological Microscopes.

Extension of Thermogravimetric Techniques

Many applications for the comparatively new techniques of thermogravimetry (measurement of weight change through a heat-time cycle) have been discovered in the fields of chemistry and metallurgy. In order to extend these studies into the critical areas where high temperatures and high vacuums are required, specialized apparatus has been needed.



The new Chevenard TH59 Thermobalance has been developed for routine and research studies in programmed temperature cycles up to 1500°C with specimens (up to 50 grams in weight) in a high vacuum or any desired controlled atmosphere. Recording is accomplished by a photoelectric spot-follower system of novel design. Very small weight changes can be shown as a function of time or of time and temperature.

A Water Immersion Objective

Although water immersion objective lenses are not well known to most microscopists, they do have important advantages for some work. Use of such an objective in place of the normal "high-dry" gives increased resolution and, as this lens is quite insensitive to small differences in cover glass thickness, much improved over-all performance.

Of particular importance is its use for the high-power examination of specimens which are not mounted with a cover glass. In this application the use of water is much more convenient (and, probably, more suitable) than would be the use of an oil-immersion high power objective.

The Cooke objective has an initial magnification of 50, a Numerical Aperture of 1.00 and a working distance of 0.5mm.

The McArthur Microscope

Small microscopes for use in the field have been offered sporadically by many different makers over the years. In such designs it has been usual to obtain the maximum in portability and convenience at the expense of the standard of optical performance ordinarily obtained with the conventional microscope.



The McArthur Microscope shown was originally designed for malaria diagnosis and control work in the field in Southeast Asia. It can be quite easily carried in a coat pocket, but retains all the performance advantages of a full size instrument. A full range of achromatic and fluorite objectives is available as well as dark ground accessories. Illumination can be by mirror or by a battery or transformer operated built-in light source.

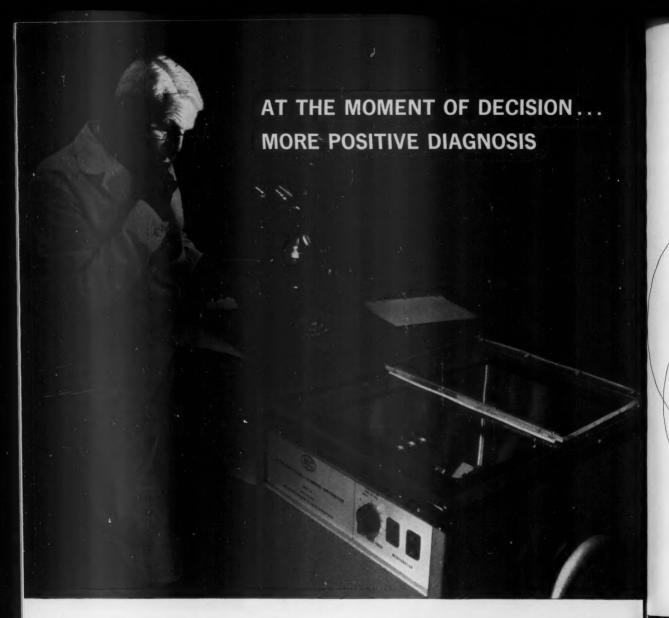
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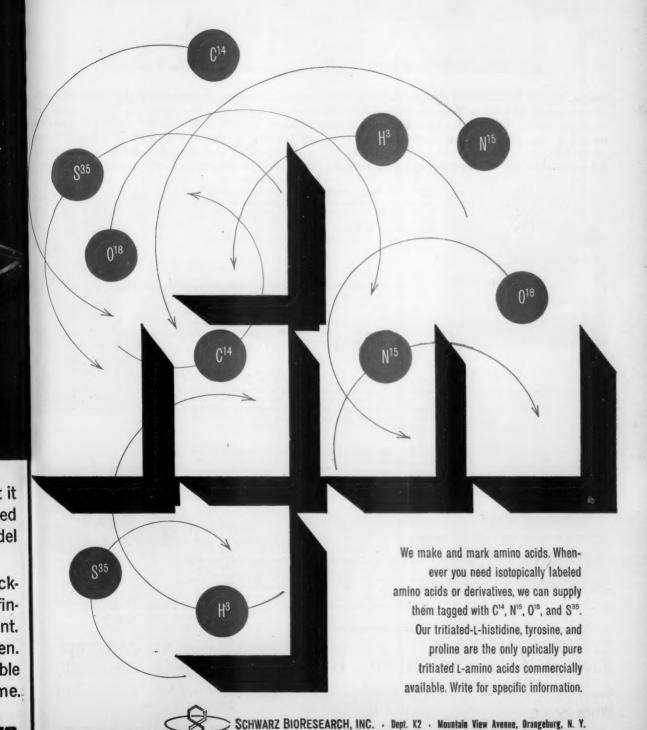
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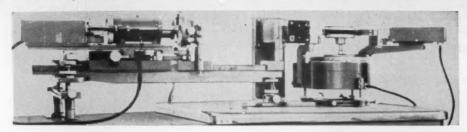
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LEFT The Rigaku High Temperature Specimen Holder is used for investigations, at high temperatures, of solubility changes as well as structural changes in the test sample. This precision instrument maintains a temperature gradient of plus or minus 5% at temperatures up to 1500 °C, in vacuum or with atmospheres such as air or inert gas.

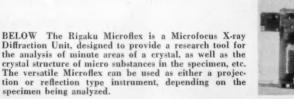
> RIGHT The Rigaku Continuous High Temperature Camera has been designed to make a continuous record of x-ray diffraction patterns of crystal specimens, in series, on film. The camera has a unique ability to capture ever-changing x-ray diffraction patterns, and features a high vacuum system, high maximum tempera-ture and simplified operation.





LEFT The Rigaku Rota Unit provides the high power required for rapid analyses. Current of 100 mA at 50 KV are available from various target materials. The water cooled rotating anode is postively sealed to preclude water leaking into the vacuum. This highly reliable re-search tool can be used with solids, liquids or gases.

RIGHT The Rigaku Low Temperature Specimen Holder is used to investigate, at low temperatures, solubility and crystal structure changes in the specimen under survey. The temperature of the specimen is lowered to -190°C, using liquid nitrogen as the refrigerant. The investigation can be made with the specimen in an atmosphere of air, inert gas, or a vacuum.





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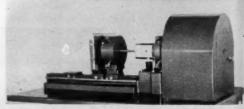
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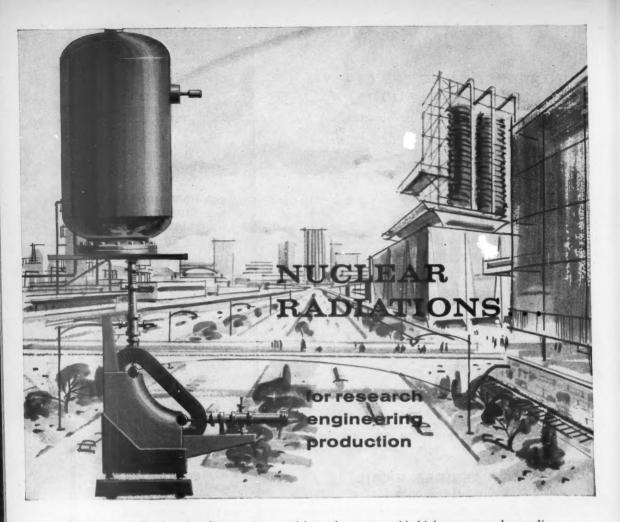
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Model Teaching

One of the more imaginative of the current efforts to improve the teaching of mathematics in elementary school involves the use of a set of wooden rods of differing lengths, sometimes called Cuisenaire rods after Georges Cuisenaire, the Belgian teacher who developed them. The rods serve as a model for work in arithmetic, and certain other parts of mathematics, much as the figures sketched in high school geometry serve as models for the proofs of the theorems. Use of models in the solving of problems has an honorable place in the teaching of mathematics, not to mention the creation of new mathematical ideas. There is the pitfall in such use, however, of becoming so zealous in the manipulation of the model as to loose sight of the mathematics the model is supposed to illuminate.

The wooden rods are square in cross section, 1 cm by 1 cm. They come in ten lengths, from pieces 1 cm long through pieces 10 cm long. In teaching arithmetic, the rods could be used, for example, to represent the equation "2+3=5" by setting a 2-cm rod end to end with a 3-cm rod, and then covering both rods with a 5-cm rod. And the rods could be used to represent the equation " $2\times 3=3\times 2$ " by placing two 3-cm rods side by side, and then covering the resulting rectangle by setting three 2-cm rods crosswise to the first rods. The children learn not only by looking at the rods and seeing that the two sides of an equation are equal, but also from handling the rods and feeling this equality.

Many other, and more ambitious, things can be done with the rods, but the problem the model poses is that even those persons who agree about its effectiveness in teaching disagree on when, for a given problem, that effectiveness ceases. Thus, in the teaching of fractions, some teachers use the rods to represent a given fraction by placing two rods in an ordered arrangement. To represent the fraction "1/2," for example, the 1-cm rod could be placed above the 2-cm rod. Other teachers find, however, that it is in just this kind of use that the rods turn from an aid to thought into a hindrance to thought.

The difficulty with this representation of fractions, it is argued, is that the model begins to lose its one-to-one correspondence with the mathematical work it is supposed to illustrate. Consider, for example, the representation of "1/2" by a 1-cm rod over a 2-cm rod and of "1/10" by a 1-cm rod over a 10-cm rod. In arithmetic there is the inequality "1/2 > 1/10," yet, taking the two representations together, the representation of "1/2" appears not larger, but smaller, than that of "1/10." There are now two possibilities, the argument continues. Either this lack of correspondence will confuse the child or it will not. If it confuses him, the model should be abandoned. If it does not confuse him, the model should also be abandoned, because this simply shows that the young scholar is sophisticated enough to use pencil and paper. It will not bother him that the written mark "1/10" looks larger than the written mark "1/2."

Some meaningful work with the rods can still be done on fractions. To obtain a representation of "1/4," for example, let the 4-cm rod represent "1." The 1-cm rod will then represent "1/4"—the rods are not labeled with numbers, but rods of different lengths are distinguished by different colors. The Cuisenaire rods are surprisingly helpful if used properly, but wisdom in introducing a model in teaching mathematics must be matched by equal wisdom in knowing when the model must be abandoned. In using a model, the danger lies in loving it not wisely but too well.—J.T.

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SCIENCE

The Earth's Free Oscillations

Large earthquakes cause low-frequency vibrations which give new information about the earth's interior.

Gordon J. F. MacDonald

The great Chilean earthquake of 22 May 1960 excited the earth's free modes of vibration, and these were observed for the first time. The detection of the free modes broadens the spectrum over which a geophysicist may look into the earth's dark interior. Prior to 1960, almost all information regarding the earth's interior had been derived from detailed investigations of times of arrival of elastic-body waves as recorded by seismographs. The elasticbody waves travel different paths through the earth and contain most of their energy in the high-frequency part of the spectrum (10 to 0.1 cy/sec). The interpretation of arrival times is based on a ray theory similar to the ray theory of geometrical optics. The use of lowfrequency normal modes as a tool for the investigation of the earth is thus somewhat analogous to the astronomer's use of radio frequencies as a supplement to observations in the visual range.

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Free Vibrations of an Elastic Sphere

The observation and interpretation of the free oscillations is the latest chapter in an investigation begun in 1882 by the noted mathematical physicist Horace Lamb. If an elastic solid is tapped by a hammer, the elastic disturbance is initially carried outward by two traveling waves. The fast wave (P wave) carries with it the compression and rarefaction of ordinary sound. The slow

wave (S or shear wave) transmits particle motion at right angles to the direction of propagation. If the solid is sufficiently isolated from the surroundings, reflections from boundaries may set up standing waves. The solid then rings or vibrates at the normal mode frequencies. Lamb (1) showed that the free vibrations of an elastic sphere can be classified into two groups: The toroidal or torsional oscillations are those in which a particle executes motion on a spherical surface; there is no radial component of motion. The toroidal oscillations unite to form the familiar horizontally polarized shear waves (SH waves) of classical seismology. The spheroidal oscillations combine both radial and tangential motion to produce compression and rarefaction. A degenerate spheroidal oscillation involves only radial motion; the entire sphere expands and contracts.

The notation adopted to describe the earth's free oscillations is similar in many ways to the notation used in atomic spectroscopy, thus reflecting the common mathematical structure of these two fields. The solution to the equations of motion of an elastic sphere can be separated into a function dependent upon radius and a function dependent on the angular coordinates. The angular function is written as a sum of surface spherical harmonics

$$X_i^m = P_i^m \ (\sin \ \theta) \ e^{i \ m\phi} \tag{1}$$

P₁^m is the associated Legendre function. If we use a geographical coordinate system, ϕ is the longitude and θ is the latitude. The time dependence can be included in the exponential as exp [i (mb $-\omega t$)], where ω is the angular frequency. This represents a wave traveling with a speed of m/w radians per second. If m is positive, the wave travels from west to east; if m is negative, it travels from east to west. The two signs of m are symmetrical in a stationary sphere. Rotation destroys the symmetry and creates important differences between waves traveling from west to east and waves traveling from east to west. The numbers m and l are familiar in quantum mechanics as the magnetic and azimuthal quantum numbers, respectively; l and m must assume integral values, and these integers determine the surface pattern of deformation associated with a particular free oscillation. The number of lines of vanishing displacement associated with the angular coordinate θ is l-|m|; the number of nodal lines associated with the angular coordinate o is m. There will also be surfaces of zero particle displacement associated with the radial function.

Free oscillations can thus be characterized by three integers; l and m determine the pattern of displacement on the spherical surface, and n determines the number of internal nodal surfaces. The notation that has been adopted is "Si". "T1" for spheroidal and toroidal oscillation, respectively. The expression "T:" denotes a toroidal oscillation with n radial nodal surfaces and a displacement pattern on the surface of the sphere fixed by the surface spherical harmonic with ordinal numbers 1 and m. In the So oscillation, a sphere alternately assumes a prolate and an oblate form; this is sometimes termed the football mode. In the ${}_{\circ}T_{\circ}$ oscillation, one hemisphere differential rotates or twists relative to the other.

Lamb treated a homogeneous uniform sphere. It was recognized by Jeans that

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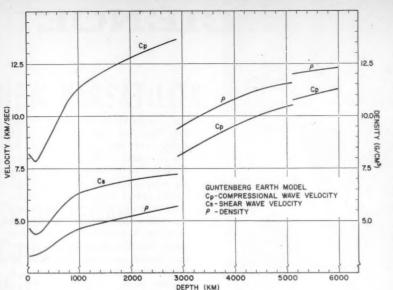


Fig. 1. The variation of the compressional- and shear-wave velocity and density within the earth. [According to Gutenberg (6)]

gravity influences the spheroidal oscillations, since these involve radial motion. At low frequencies, the gravitational forces are of the same order of magnitude as forces produced by elastic distortion; indeed it can be shown that over large regions of the earth there is a delicate balance between the two forces. A method of treating gravitational effects was suggested by Rayleigh (2) and was later employed by Love (3) and Jeans (4). The solution to the problem of gravity failed to remove all difficulties in computing the periods of the free oscillations. The earth is inhomogeneous; the density and elastic properties vary in a radial direction. It is now known that the inner half of the earth contains a liquid core with a small inner core that is thought to be solid.

The reduction of observations of numerous earthquakes at many stations leads to estimates of the variation of the P- and S-wave velocity. These velocities can be combined with the moment of inertia and mass of the earth to obtain an estimate of the variation of density within the earth (5)°. One such model of the earth's interior was constructed by Gutenberg (6, 7) (see Fig. 1). The characteristic feature of the Gutenberg model is a dip in the seismic velocities, beginning at the crust-mantle boundary and extending to a depth of 150 kilometers. Alternative models have been constructed by Bullen and Jeffreys (5). In these models the seismic velocities monotonically increase with depth; there is no region of low velocity (see Fig. 2). A particular model suggested by Bullen (Bullen model B) contains an inner core of much higher density (17.9 g/cm3) than that postulated in the Gutenberg model.

The extension of the theory for a homogeneous sphere to an inhomogeneous earth involves formidable computational problems. Stoneley, in 1926 (8), suggested a variational method, and much of the work since that date has been based on this approach. Pekeris and his coworkers proposed direct numerical methods, and these methods made possible a massive computational effort in which electronic computing machines were employed (9-11).

The effects of the inhomogeneous elasticity and density on the free oscillations are illustrated in Figs. 3 and 4, where the Gutenberg-model earth is contrasted with a homogeneous model in which the elasticity equals the aver-

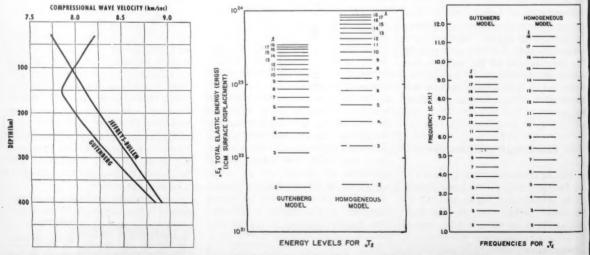


Fig. 2 (left). Comparison of the Gutenberg and the Bullen models in the upper mantle. Fig. 3 (middle). Total elastic energy in the fundamental toroidal oscillation. The energy is normalized to a 1-centimeter surface displacement. Fig. 4 (right). Comparison of resonant frequencies for the toroidal oscillations in the Gutenberg and the homogeneous models. [Figs. 3 and 4, after MacDonald and Ness (10)]

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Fig. 5. (top). Total elastic energy per unit radius in the toroidal oscillations for the Gutenberg model. [After MacDonald and Ness (10)]. Fig. 6 (middle). Power spectrum of the gravity record after the Chilean earthquake of 22 May 1960. University of California (Los Angeles) earth-tide gravimeter; recording period, 23-27 May; 110-hour record; interval, 1 minute; sensitivity, 0.1 µgal. [After Ness, Harrison, and Slichter (17)]. Fig. 7 (bottom). Power spectrum of the quiet period one month after the Chilean earthquake. University of California (Los Angeles) earth-tide gravimeter; recording period, 23-28 June; 116-hour record; interval, 1 minute; sensitivity, 0.1 µgal. [After Ness, Harrison, and Slichter (17)]

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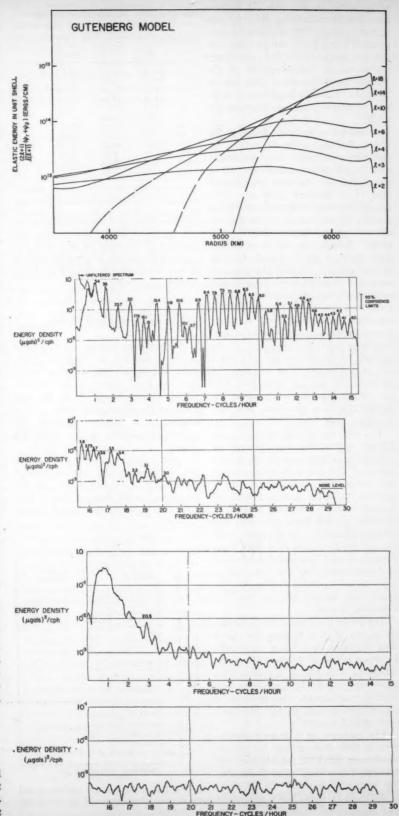
age elasticity of the Gutenberg model. The energy levels shown in Fig. 3 are normalized to provide a 1-centimeter displacement at the surface. About 3 × 10" ergs are required to produce this displacement, with a . T2 surface pattern in both the homogeneous and the inhomogeneous models. At higher modes and higher frequencies (Fig. 4) it takes more energy to form the more complicated surface pattern of displacement while maintaining a maximum surface amplitude of 1 centimeter. The needed energy is greater in the homogeneous model, since the near-surface rigidity is larger than in the Gutenberg model. The difference increases with increasing value of the mode number 1.

The energy is more or less evenly distributed over the entire mantle at low mode numbers (see Fig. 5). At higher mode numbers the elastic energy is concentrated in the outer layers of the mantle. The ${}_{\circ}T_{\circ}$ oscillation involves the mantle; the ${}_{\circ}T_{\circ}$ oscillation is confined to the upper few hundred kilometers.

A further development in the theory should be noted. Jeans (4) showed that the free oscillations excited by an earthquake could be regarded as a system of dispersive surface waves and other waves diffusing into the earth's interior. Jeans established the correspondence of normal mode theory and ray theory in an elegant way. The raywave theory emphasizes the high-frequency part of the spectrum; the normal mode theory, the low frequencies.

Observation of the Earth's Free Oscillations

Despite the considerable theoretical efforts, only recently was an attempt made to observe the earth's oscillations. Benioff constructed a strain-measuring



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seismometer in the form of a silica glass rod 24 meters long, with the particular purpose of investigating the low-frequency spectrum. Benioff suggested that an apparent 57-minute periodicity visible on the strain records of the Kamchatka earthquake of 1952 was the ${}_{\circ}S_{2}$ mode. This single suggestion of Benioff's prompted extensive computational work.

A second attempt at detecting the free oscillations was made in 1958, by spectrally analyzing the background noise in the strain seismometer and in the changes of the local gravitational field (12). Between 1958 and 1960 several instrumental developments made possible the observation of the free oscillations excited by the Chilean earthquake. Benioff, at the Seismological Laboratory of the California Institute of Technology, modified the circuitry associated with the strain seismometer so that the effect of the finite-amplitude earth tides was reduced and a greater magnification was achieved. A lower noise level was achieved on the LaCoste-Romberg gravimeter operated by the Institute of Geophysics at the University of California (Los Angeles). In addition, the Lamont Geological Observatory installed a strain gauge of the Benioff type in a mine shaft near Ogdensburg, New Jersey.

The free oscillations excited by the Chilean earthquake were detected on both the gravimeter and the strain seismometer. The instruments complement each other. The strain seismometer is sensitive to strain produced both by vertical and by horizontal motion; it therefore records both spheroidal and toroidal oscillations. On the other hand, the gravimeter records only vertical accelerations and spheroidal oscillations. A combination of the observations from the two instruments permits separation and identification of the two classes of motion.

The power spectrum of the variations in gravity at Los Angeles for the 4 days following the Chilean earthquake is shown in Fig. 6. Figure 6 should be compared with Fig. 7, a record of a quiet interval of 116 hours 1 month after the earthquake. This spectrum is almost structureless, though there is a peak at 20.5 minutes.

The spectrum of a seismic disturbance is thus characterized by well-defined sharp peaks for periods that vary between 1 hour and about 8 minutes. At higher frequencies the isolated peaks begin to merge into a continuum as a result of the finite width of an in-

Table 1. Comparison of calculated and observed toroidal oscillations (in minutes).

| Order | | Oh | | |
|-------|-------------|----------------|-------------------|---------------|
| | Bullen B | Guten- berg | Guten- berg IV | Ob- served |
| 2 | 44.18 | 43.63 | 44,11 | 42.94 |
| 3 | 28.62 | 28.25 | 28.55 | 28.57 |
| 4 5 | 21.92 | 21.64 | 21.86 | 21.95 |
| 5 | 18.09 | 17.86 | 18.04 | 18.02 |
| 6 | 15.55 | 15.37 | 15.52 | 15.51 |
| 7 | 13.72 | 13.60 | 13.72 | 13.75 |
| 8 | 12.33 | 12.24 | 12.35 | 12.35 |
| 9 | 11.23 | 11.17 | 11.26 | 11.24 |
| 10 | 10.35 | 10.29 | 10.38 | 10.33 |
| 11 | 9.59 | 9.56 | 9.64 | 9.614 |
| 12 | 8.95 | 8.94 | 9.01 | 9.065 |
| 14 | 7.92 | 7.93 | 7.99 | 7.985 |

dividual peak and the increased number of peaks. Similar observations and analyses of the resulting data were carried out on records of strain by Benioff, Press, and Smith (13, 14) and by Alsop, Sutton, and Ewing (15).

Determination of Earth Models

A comparison between the spheroidal modes calculated by Peckeris, Alterman, and Jarosch (16) and those measured by Ness, Harrison, and Slichter (17) is shown in Fig. 8. At low frequencies the observations favor neither model, but at higher frequencies the observations closely fit the Gutenberg model.

Table 1 gives a comparison between the calculated and the observed toroidal oscillations. In addition to data for the Gutenberg model shown in Fig. 1, data for a modified Gutenberg model, Guten-

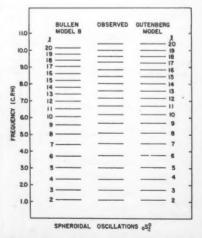


Fig. 8. Comparison of the calculated and the observed frequencies of the spheroidal oscillations.

berg IV, are included. The observed periods are consistently shorter than those of the Gutenberg model in the low-order oscillations, and the periods are more nearly equal in the high-order oscillations. This suggests that, on the average, the Gutenberg model has too high a rigidity. The perturbation of the Gutenberg model to form Gutenberg IV is controlled by the fact that the low-order oscillations involve the entire mantle of the earth while the higher-order oscillations reflect the properties of only the outer few hundred kilometers. The Gutenberg IV model is produced by reducing the shear-wave velocity throughout the lower part of the mantle by 2 percent and maintaining the Gutenberg velocity distribution in the outer 400 kilometers.

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Comparison of the toroidal and spheroidal oscillations with models of the earth strongly indicates a preference for a model with a region of low velocity. This provides additional supporting evidence for the existence of a region of low velocity (18).

In the Gutenberg model the velocity increases everywhere in the mantle but in a thin, near-surface region. The conditions which give rise to the anomalous decreasing velocity are of great interest. Laboratory measurements show that in silicates the wave velocity increases with increasing pressure; pressure stiffens a rock. An increase in temperature has the opposite effect, decreasing the wave velocity. In the outer regions of the earth, both pressure and temperature increase; the velocity decreases if the increase in temperature wins out over the increase in pressure. An extrapolation of laboratory data indicates that a gradient of 6 to 7 degrees per kilometer is sufficient to produce a decrease in velocity (10, 19). One can then inquire as to what distributions of radioactive heat sources and thermal conductivity are sufficient to give the required critical temperature gradient and at the same time account for the heat flowing from the earth's interior.

It is generally assumed that the radioactive heat sources are concentrated toward the surface. The concentration is greater under continents than under oceans. The thermal conductivity may vary because of the contribution of radiation at high temperatures. The combination of the near-surface concentration of heat sources and a thermal conductivity increasing with depth requires that the steepest temperature gradient exist in the upper mantle. If the low-velocity zone is in-

deed caused by a high temperature gradient, then the low-velocity zone should begin at the base of the crust rather than at some greater depth (100 to 200 kilometers), as has been suggested on the basis of studies of nearby earthquakes.

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The thermal conditions that could give rise to the low-velocity zone are illustrated in Figs. 9 and 10. Conditions approximating the upper mantle under oceans are shown in Fig. 9. The radioactivity is concentrated in the upper 430 kilometers, and there is no further concentration of radioactivity near the surface. The calculated temperature gradient exceeds the gradient required to produce a low-velocity zone at depths ranging from 100 to 150 kilometers. Figure 10 illustrates the conditions that might be expected under continents. The radioactivity is distributed over the upper 430 kilometers, but half of it is placed above 30 kilometers. The nearsurface concentration of radioactivity reduces the temperature gradient, and a low-velocity zone exists at depths down to 50 to 100 kilometers. The calculations suggest that there should be a marked difference in the extent of the low-velocity zone under continents and oceans. The low-velocity zone should extend to greater depths and be better developed under ocean areas.

The low-velocity zone might be due to large-scale chemical inhomogeneity in the upper mantle. According to this hypothesis, the low-velocity zone could be found at greater depths. Detailed studies of surface waves and artificial explosions are needed for an understanding of the origin of the low-velocity layer.

Earthquake Energy

Estimates of the energy released during a large earthquake differ by factors of 10. A source of uncertainty is the energy contained in the low-frequency end of the spectrum. The energy levels of the toroidal oscillation shown in Figs. 3 and 4 can be combined with observations on particle displacement at the surface to yield an estimate of the energy in the earthquake at these low frequencies. The displacement obtained by the strain seismometers in the Chilean earthquake give an energy density in the ${}_{\circ}T_{\circ}$ mode of 5×10^{18} ergs per cycle per hour. The total energy in the toroidal oscillations that have a period greater than 9 minutes is about 1000 ergs. If there is equipartition of energy between the toroidal and the spheroidal oscillations, then about 10²¹ to 10²² ergs of energy were initially present in oscillations with periods greater than 1 minute. These figures should be compared with the 10²¹ ergs estimated for total elastic energy released by the Chilean earthquake.

Line Structure

Ness (17) and Smith (13), in reducing the data from the Chilean earthquake, noted that the low-frequency spectral peaks appeared as doublets or triplets instead of single lines as would be expected for a stationary elastic sphere (11). Rotation destroys the symmetry with respect to the integer m in Eq. 1, and the degeneracy associated with the symmetry is removed. The effect of rotation on the oscillations can be qualitatively understood by recalling that a free oscillation is composed of a number of running waves. Waves traveling in the direction of the earth's rotation are carried forward relative to waves traveling in the opposite direction. The net effect is that the total pattern of surface deformation rotates relative to the earth. The local effect is cause the vibrating particles to precess, much in the manner of a Foucault pendulum. The rotational splitting is analogous to the Zeeman effect in spectroscopy, where a magnetic field removes the degeneracy with respect to the quantum number m. Detailed calculations of the splitting in spheroidal and toroidal oscillations have been made (10, 20). The calculated splitting is in agreement with the splitting observed in the low-order spheroidal oscillations, an oscillation of order l being split into 2l + 1 peaks. The fine structure of the lowest-order toroidal oscillation is in doubt and the line .T. presents a number of problems. It should be remarked that rotational splitting of the elastic vibrations is analogous to the effect of rotation on the axisymmetric oscillations of a fluid sphere. These oscillations have been studied in detail by astrophysicists concerned with variable stars. Indeed, Cowling and Newing (21) obtained an expression for the rotational frequency shift in the free oscillations of a star that is identical in form to that describing the effect of rotation on the elastic vibrations of the earth.

If the earth were a perfectly elastic body, then the spectral peaks should show up as individual lines broadened

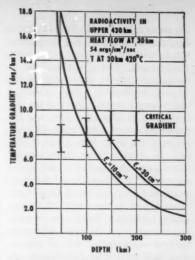


Fig. 9. Computed thermal gradient under a typical ocean. The critical temperature gradient required to produce a low-velocity zone is indicated by the heavy vertical lines.

only by the data-reduction techniques (instrumental broadening). The deviations from perfect elasticity or fluidity results in a natural broadening of the lines. The degree to which a given line is broadened, or, alternatively, the rate at which a given peak decays, provides, in time, a measure of the anelastic properties of the earth.

The distribution of the anelastic properties can be obtained by studying

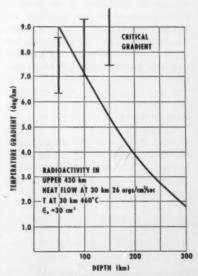


Fig. 10. Computed thermal gradient under a typical continental region. The critical temperature gradient required to produce a low-velocity zone is indicated by the heavy vertical lines.

the decay rate of oscillations of various frequencies, since differing frequencies represent different portions of the earth. Furthermore, several mechanisms of dissipation will be prominent in the various oscillations. The spheroidal oscillation of order 2 involves the entire earth, including the core, and the motion contains components of compression and shear. The radial oscillation So involves only compressional motion, and this oscillation provides a measure of the dissipation of the earth in compression. The broadening of the toroidal lines is due primarily to dissipative processes within the mantle. The interaction of the core and mantle provides an additional sink of energy. A detailed study of possible viscous and hydromagnetic effects rules out the core-mantle boundary as a major contributor to the energy loss (10).

The half width of the lines, Q, or the rate of energy dissipated per cycle per peak elastic energy is found to be about 350 for spheroidal oscillations. Thus, in spheroidal oscillation the earth rings as a rather poor bell. The estimates of the Q for toroidal oscillations are less good, but somewhat lower figures are indicated. The highest Q of all is shown by the radial oscillation. As may be noted in Figs. 1 and 2, the earth appears to be ringing in this mode of oscillation a month after the earthquake. The indicated Q is greater than 1000. The dissipation in compression is thus much less than in shear. Such a conclusion is in agreement with the suggestion by Knopoff and MacDonald (22) that the major mechanism for dissipation of small-amplitude waves in the earth is frictional rubbing across grain boundaries.

Core Problems

Smith (23), in a careful analysis, finds that the period of the fundamental toroidal oscillation is 42.94 minutes. This period is more than a minute less than the period predicted for the Gutenberg IV model, which gives a reasonable fit to the other oscillations. The deviation is in the direction one would expect if the core-mantle boundary were partly rigid; the resonant period for a mantle with a rigid inner surface is 32.1 minutes. A possible explanation of the apparent stiffness involves the earth's magnetic field. A component of the magnetic field tangential to the coremantle boundary leaks out of the core into the conducting lower mantle. This component combines with the dipole component to give a Maxwell stress. The lower mantle is then partially glued to the core, and this leads to an apparent stiffness. If this interpretation is correct, an estimate can be made of the conductivity of the lower mantle and the strength of the magnetic field. Detailed studies of toroidal oscillations of low frequency may lead to fundamental information regarding the electromagnetic properties of the core and lower mantle.

Slichter (24) has emphasized the presence of a peak at the low-frequency end of the spectrum that is not theoretically predicted (see Fig. 1). A possible interpretation of this peak is that it represents the jiggling of the solid inner core, and that the jiggling is dampened by interaction with the fluid outer core. The problem remains open, however, since the reality of the peak remains to be established and the detailed dynamics of the inner-core oscillations remain to be explored.

Conclusion

The development of sophisticated instrumentation has permitted investigation of the interior of the earth through use of a new frequency range. The results from a single earthquake have provided abundant new information regarding the earth's interior. Oscillations are excited only by large earthquakes. Over the period of the next few years we may expect a few large earthquakes, and the associated vibrations will yield new knowledge on the internal constitution of our earth.

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Strontium-90 Absorption by Deciduous Teeth

Analysis of teeth provides a practicable method of monitoring strontium-90 uptake by human populations.

Louise Zibold Reiss

In 1958 Kalckar proposed that deciduous teeth collected on a large-scale, world-wide basis could be used to study the accumulation in children of radioactive material from nuclear test fallout (1). Strontium-90, which follows the metabolic pathways of calcium, is deposited in bones and teeth. Absorption is greatest during the period of growth. Thus, children, who presumably have a higher biological radiosensitivity than adults, accumulate the radioisotope more readily. The amount of radiation delivered to bone marrow, with possible effects in leukemogenesis, is important.

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Monitoring strontium-90 absorption in children is made difficult by the scarcity of adequate bone samples, which must be obtained at autopsy. By contrast, deciduous teeth, which have a chemical composition similar to bone, are plentiful and should be readily available for study.

While the suggestion that teeth could be used for monitoring strontium-90 uptake in bones was soundly based on then available information, at the start the feasibility of such a project was not clear. There was doubt whether the community cooperation required by a large-scale collection program could be obtained. How large the samples of teeth would have to be to yield meaningful data was not known. Although similarities of strontium and calcium metabolism in teeth and bones were suspected, there was no direct evidence that teeth and bones developing in the same biologic environment accumulated these minerals in the same ratio. In addition, the relative effects of prenatal and postnatal tooth development on strontium-90 deposition might introduce difficulties in interpreting the data.

The present article is addressed to these questions. The results reported show that deciduous teeth can be usefully employed as a means of monitoring strontium-90 uptake in man.

Tooth-Collection Program

The decision to start a tooth collection from the St. Louis area was reached in December 1958 (2). There was a great sense of urgency about starting the collection, since teeth that were then being shed were formed before significant fallout had occurred and thus were expected to yield essential baseline information. An empirical yearly goal of 50,000 deciduous teeth of all types was set.

Since this number represented an appreciable fraction of the total number of teeth shed by the juvenile population of St. Louis, the cooperation of the community was required. Sponsorship of the tooth survey was undertaken by a citizens' group, the Greater St. Louis Citizens' Committee for Nuclear Information (3) in cooperation with the schools of dentistry at Washington and St. Louis Universities (4). In order to explain the purposes of the survey to the public without arousing alarm as a result of misunderstanding, a program of community education in the area of nuclear energy was conducted by speakers of the committee. Community health officials, the St. Louis Dental Society, private dentists and dental clinics, all school superintendents, librarians, the

St. Louis Pharmaceutical Association, and many church, YMCA, YWCA, and Scout groups supported the program. Newspapers and radio and television stations generously provided publicity as a public service.

In order to obtain the necessary data relevant to environmental factors that might affect the uptake of strontium-90 by teeth, certain background information was requested with each tooth submitted. The standard form included questions concerning the child's date of birth, the date the tooth was lost, the residence of the mother during pregnancy, the residence of the child during the first year of life, duration of breast feeding, duration of formula feeding, kind of milk used in the formula, and other milk used during the first year. The questionnaire was a detachable section of the form and became a permanent record card for each tooth.

One million tooth survey forms have so far been distributed through schools, libraries, dental organizations, dentists, pediatricians, and other agencies. After a tooth, with background information, has been received by mail, the donor is sent a button ("I gave my tooth to science") and a new information form. Teeth are then cataloged by members of the Women's Auxiliary of the St. Louis Dental Society. Each tooth is unwrapped and placed in a separate, numbered envelope. This file number is added to the corresponding record card, which is checked for completeness. Parents are contacted by telephone and asked to supply missing information. When several teeth from the same child arrive with a single form. additional cards are prepared. A pedodontist (5) then examines each tooth and records the type and the presence of caries, amalgam, or root on the record card. Teeth are stored by number. Record cards are filed in categories according to month of birth, type of tooth, type of infant feeding (breast or bottle), and presence or absence of

The dissemination of forms, cataloging, record keeping, and filing involved a great deal of labor, which was accomplished with the aid of large numbers of dedicated volunteer workers (6). The only salaried person was a secretary.

In the 2½ years since January 1959, 61,000 teeth have been collected. Of these, 14,500 were obtained in 1959, 27,000 in 1960, and 19,500 in the first

The author, an internist, was vice-president and director of the Baby Tooth Survey, Greater St. Louis Citizens' Committee for Nuclear Information, 1959-1961.

Table 1. Concentration of strontium-90 in three pools of teeth and bones obtained from stillborn infants. The bones were analyzed individually, and the errors indicated reflect the standard errors derived in the separate analyses. Only one analysis could be made for each pool of teeth; the errors refer to standard deviations due to analytical errors.

| Pool of infants | | Concentration $(\mu\mu c)$ of Sr ⁹⁰ per gram of Ca) | | | | |
|-----------------|-------|--|-----------------|--|--|--|
| | mants | Bone | Tooth pool | | | |
| | 10 | 1.04 ± 0.105 | 1.55 ± 0.09 | | | |
| B | 15 | 1.22 ± 0.119 | 1.08 = 0.08 | | | |
| C | 18 | 1.27 = 0.123 | 1.14 ± 0.08 | | | |

half of 1961. At the present collecting rate, 750 teeth are received, on the average, every week.

Approximately 10 percent of the teeth received thus far were sent from beyond the confines of the geographical area under study, which included Greater St. Louis and environs within 100 miles. Another 15 percent came from children who had lived elsewhere at the time of birth. Over 95 percent of the local teeth were accompanied by all the background information requested on the form.

Of 20,439 teeth collected from children born in the St. Louis area during 1959 and 1960, there were 11,656 incisors, 2652 cuspids, 3161 first molars, and 2967 second molars. The peak birth years for child donors of incisors were 1952 and 1953. For donors of cuspids and first and second molars, the peak year of birth was 1950. The percentages of those breast-fed for 1 month or longer were 29, 50, 54, and 38 percent, respectively, for donors of incisors, cuspids, first molars, and second molars. The incidence of caries among incisors was 5.4 percent; among cuspids, 15.2 percent; among first molars, 67.1 percent; and among second molars, 78 percent. No difference in the incidence of caries in breast- and bottle-fed groups was noted.

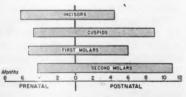


Fig. 1. Approximate periods of calcification of deciduous teeth by types. [Based on a table by Schour and Massler (19) and modified in accordance with recent studies of Kraus (8)]

Strontium-90 Analyses of Shed Deciduous Teeth

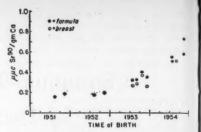
After calcification, tooth enamel is a nonviable structure that can be altered only be mechanical means and by ionexchange from surface contacts or permeation (7, p. 91). Dentin continues to be laid down in very small amounts during the life of the tooth (7, p. 139). For all practical purposes, however, the tooth may be considered a stable structure and can thus be expected to retain the mineral composition acquired at the time of its formation. The deciduous tooth, therefore, promises to provide information concerning the amount of strontium-90 uptake during the year of the donor's birth, some 5 to 12 years prior to the time of shedding.

Calcification begins after the 12th intrauterine week (8) and becomes complete during the first year of life (7, p. 45). The exact calcification period is still in doubt, and much individual variation occurs (8). Approximate periods of calcification are shown in Fig. 1. Root development continues after the first year, but since the root is resorbed before shedding, this time period is not involved in the study of shed teeth.

In the study under discussion, incisor teeth from children born during the last two quarters of the years 1951 through 1954 were analyzed, if the mothers had spent the prenatal period in St. Louis and the children had lived in the area during the first year of life. Severely decayed teeth and teeth of children fed milk substitutes were excluded. The number of teeth from one child was limited to two per sample. The child donors of teeth in samples designated "breast-fed" had been breast-fed for 1 month or more; donors of teeth in samples designated "bottle-fed" had received no breast milk.

Root material was removed from each tooth by grinding off all fragments below the cervical region of the tooth. Small decayed areas and amalgam were ground off. These were present in about 3 percent of the teeth. For studies of teeth from donors born in the years before 1953, a sample weighing about 12 grams, comprised of about 90 incisor teeth, was used. Because of the substantial increase in environmental strontium-90 in 1953 and later, the sample size was reduced in studies of teeth from donors born in 1953 and 1954 (Table 1).

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Fig. 2. Early time course of deposition of strontium-90 in deciduous teeth. The unexpectedly small difference between findings for teeth of formula-fed and teeth of breast-fed children may reflect the relatively brief period of breast feeding in some samples.

bers of teeth for the three component months were pooled. The teeth were selected at random from all teeth in the collection that fulfilled the requirements of the sample.

All strontium-90 analyses were made at Isotopes, Incorporated, Westwood, New Jersey, by a modification of the method of Volchok (9).

The data are shown in Fig. 2 and Table 2. The upward trend with time may be correlated with increasing dietary concentrations of strontium-90.

A small fraction of the strontium-90 in normally shed teeth is undoubtedly added after tooth formation has been completed. A high degree of permeability of intact enamel and dentin to urea has been demonstrated by Wainwright and Lemoine (10). Armstrong and Barnum (11) reported calcium-45 and phosphorus-32 in the teeth of mature animals shortly after administration of the tracers. The extent to which strontium-90 may appear in teeth as a result of exchange phenomena is not

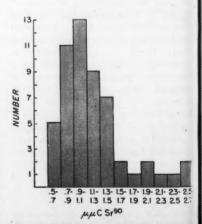


Fig. 3. Frequency distribution of strontium-90 concentration in fetal skeletons.

clear at present. The concentration of approximately 0.18 micromicrocurie per gram of calcium in 1951 and 1952 undoubtedly represents a maximum estimate for this mode of strontium-90 accretion, since some environmental strontium-90 was already present in these years.

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It had been expected that the concentration of strontium-90 would be lower in deciduous teeth of breast-fed than in those of bottle-fed donors. A recent study by Lough, Hamada, and Comar (12) showed that the ratio of strontium-90 to calcium in breast milk was only one-tenth that in the mother's diet. Furthermore, Widdowson et al. (13) have recently reported negative strontium balances in breast-fed babies. For these reasons, the finding of comparable concentrations of strontium-90 in teeth of bottle-fed and breast-fed children was surprising, and additional studies are indicated. In only one sample (Table 2, No. 11) did there appear to be a substantial difference. The duration of breast feeding was 6 months or longer for 35 percent of the tooth donors represented by this sample. For other samples, only 15 to 21 percent of the donors had been breast-fed for this length of time. In future studies, the requirement of a minimum period of breast feeding of 4 months for donors of samples designated "breast-fed" may magnify differences that are barely suggested in the initial study.

Comparison of Strontium-90 Uptake by Teeth and Bone

If the concentration of strontium-90 in teeth is to serve as an indication of the concentration in bone, it is important to know the relative rate of uptake of strontium-90 and calcium by teeth and bones developing in the same biological environment. This information was sought by comparing the ratios of strontium-90 to calcium in teeth and in bones of stillborn infants (14).

Deciduous teeth were dissected from the jaws of 43 stillborn infants with crown-to-heel measurements ranging from 19 to 21 inches. The teeth were air-dried to a constant weight, and three pools of teeth were prepared. Within a given pool each fetus contributed an equal weight of tooth material.

The bones were freed of much soft tissue, by dissection, and heated in water at 170°C for 5 hours. The remaining soft tissue was then removed manually,

Table 2. Concentrations of strontium-90 in deciduous teeth.

| Sample No. | Date of birth | | Infant | Number | Weight of sample | Calcium | Strontium-90 |
|---------------|---------------|---------|---------|--------|------------------|---------|----------------------|
| | Year | Quarter | feeding | teeth | (g) | (g) | (µµс per gram of Ca) |
| 1 | 1951 | 3 | Formula | 90 | 11.67 | 3.31 | 0.155 = 0.029 |
| 2 | 1951 | 4 | Formula | 90 | 13.80 | 3.66 | 0.193 ± 0.029 |
| 3 | 1952 | 3 | Formula | 90 | 12.31 | 3.45 | 0.188 ± 0.021 |
| 4 | 1952 | - 4 | Formula | 90 | 10.18 | 2.84 | 0.204 ± 0.036 |
| 5 | 1953 | 3 | Formula | 90 | 9.23 | 2.60 | 0.324 ± 0.030 |
| 6 | 1953 | 3 | Formula | 75 | 9.15 | 2.67 | 0.320 ± 0.050 |
| 7 | 1953 | 3 | Breast | 66 | 8.88 | 2.34 | 0.270 ± 0.050 |
| 8 | 1953 | 3 | Breast | 72 | 9.59 | 2.70 | 0.286 = 0.025 |
| 9 | 1953 | 4 | Formula | 75 | 8.48 | 2.47 | 0.40 ± 0.030 |
| 10 | 1953 | 4 | Formula | 78 | 8.33 | 2.26 | 0.357 ± 0.034 |
| 11 | 1953 | 4 | Breast | 66 | 7.75 | 2.27 | 0.260 ± 0.040 |
| 12 | 1953 | 4 | Breast | 72 | 8.27 | 2.33 | 0.369 ± 0.025 |
| 13 | 1954 | 3 | Formula | 72 | 7.06 | 2.02 | 0.500 ± 0.070 |
| 14 | 1954 | 3 | Formula | 81 | 8.13 | 2.32 | 0.545 ± 0.035 |
| 15 | 1954 | 3 | Breast | 75 | 8.06 | 2.24 | 0.509 ± 0.042 |
| 16 | 1954 | 3 | Formula | 75 | 8.11 | 2.28 | 0.581 ± 0.025 |
| 17 | 1954 | 3 | Formula | 78 | 7.71 | 2.15 | 0.725 ± 0.058 |

and the bones were dried for 5 hours at 220°C. Total skeletons were analyzed individually. Three skeletons were analyzed in three parts: skull, long bones, ribs and vertebrae.

In Table 1, the mean level of strontium-90 in the individual fetal skeletons is compared with the concentration of strontium-90 in the corresponding tooth pools. There was a close correlation in the concentration of strontium-90 in bones and in teeth, and deviations from a 1-to-1 ratio appeared to be random.

The total skeleton and the teeth of one 7-month-old infant born in February 1959 were analyzed separately. A bone level of 4.5 $\mu\mu$ c and a tooth level of 3.9 $\mu\mu$ c of strontium-90 per gram of calcium were found. The difference in concentration probably results from a relatively greater postnatal increment of bone than of tooth, as discussed later.

A comparison of strontium-90 levels found in the skull, in the long bones, and in the ribs and vertebrae of three skeletons is shown in Table 3. The variation is random and falls within the analytical error of the method. This is in agreement with the findings of Schulert (15) and Kulp (16), who reported a uniform distribution of strontium-90 in bones of infants and children.

The frequency distribution for strontium-90 concentration in the total fetal skeletons is given in Fig. 3. In conformity with previous studies (16), the distribution is skewed towards the higher concentration. The data are shown in scattergram form in Fig. 4.

In an effort to determine what factors contribute to the observed variations in strontium-90 levels in fetal bone, the dietary histories of mothers of stillborn infants born in 1959 and 1960 were analyzed. Hospital records were ab-

stracted by a trained social worker, who then interviewed the 28 mothers who could be located.

No correlation could be found between milk intake and strontium-90 levels in the infants' bone, or between findings for groups on poor and on adequate diets. A diet was classed as poor when it was grossly deficient in both calcium and protein. Nearly all the mothers ate fresh green vegetables daily, especially turnip and mustard greens. The wide variation in fetalbone levels found during the summer months may be related to the increased and more varied consumption of fresh leafy vegetables. It is interesting to note that the lowest strontium-90 level (0.53 μμc per gram of calcium) occurred in the stillborn infant of a 28-year-old mother who subsisted chiefly on a diet of white bread and meat. She drank no milk, ate no cereals, and ate vegetables or fruit once a week.

Only three of the mothers took supplemental calcium during pregnancy. No correlation with fetal levels of strontium-90 could be found.

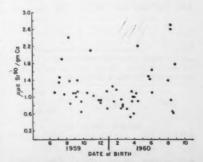


Fig. 4. Scattergram relating strontium-90 concentrations in fetal skeletons to time of birth.

Prenatal Tooth Formation

Since the portion of the deciduous tooth formed prenatally accumulates less strontium-90 than the portion formed postnatally, owing to placental discrimination against strontium (17), it is important to know how much of the tooth is formed prenatally. This was determined from the average weights of the four tooth types at birth and at the time of shedding.

Teeth from 33 full-term stillborn infants were dried to a constant weight and weighed individually. The gestational period of the fetus was determined from the hospital chart and the crown-heel length. For comparison, noncarious shed teeth were weighed. All root material was removed to the neck of the tooth so that the tooth would be representative of shed teeth as used for strontium-90 analysis. The average weight of 69 pooled upper central incisors and of 106 pooled upper lateral and lower incisors was determined; 50 cuspids, 50 first molars, and 50 second molars were weighed indi-

The results of these weighings are given in Table 4. The measurements show that in shed, rootless teeth, 32 percent of the average incisor, 6 percent of the cuspid, 17 percent of the first molar, and 5 percent of the second molar are formed prenatally.

These values do not allow for abrasion of deciduous teeth—a consideration which Bryant (18) mentions as a disadvantage in using these teeth for monitoring purposes. Only loss of the prenatally formed portion would affect the relationships given in Table 4. Since enamel deposition begins at the dentinenamel junction and proceeds peripherally (7, p. 81), it appears likely that only postnatally formed tooth would be abraded from the molars and cuspids. The incisive margins of the incisors,

Table 3. Concentrations of strontium-90 (in $\mu\mu$ c per gram of calcium) in different portions of the fetal skeleton. Errors refer to variation in the analysis (standard deviation).

| Skull | | | ong | Ribs and vertebrae | | |
|-------|-----|-------|--------|--------------------------|-------|----------------|
| | | | Sample | number | 44 | |
| 0.785 | nle | 0.033 | 0.919 | = 0.051 | 0.802 | = 0.034 |
| | | | Sample | number | 51 | |
| 0.795 | sic | 0.028 | 0.725 | = 0.032 | 0.741 | ± 0.014 |
| | | | Sample | number | 59 | |
| 1.18 | ph | 0.04 | 1.11 | = 0.04 | 1.14 | = 0.03 |

Table 4. Data on the weight of teeth from full-term stillborn infants and of shed deciduous teeth, from a study of prenatal tooth formation (see text).

| Tooth type | Average weight at birth (mg)* | Range (mg) | Average weight at shedding (mg)† | Range (mg) | Portion of shed tooth formed at birth (%) |
|--------------------------------------|-------------------------------------|---------------|--|---------------|---|
| Upper central incisors | 61 | 46-85 | 169 | Pooled | 36 |
| Other incisors | 30 | 16-54 | 96 . | Pooled | 31 |
| Weighted average for all incisors | | | | | 32 |
| Cuspids | 14 | 9-24 | 222 | 136-304 | 6 |
| First molars | 52 | 35-72 | 307 | 125-490 | 17 |
| Second molars | 32 | 13-45 | 592 | 330-862 | 5 |

^{*} Data based on teeth from 33 full-term stillborn infants. † Data based on 50 or more teeth.

however, appear to be complete at the time of birth. Abrasion thus could cause some loss of prenatally formed incisor tooth crown. Many incisors in the collection give the appearance of having been filed off down through dentin. It appears possible that in the average shed incisor only 75 to 80 percent of the prenatal portion may remain.

The degree of attrition by abrasion and the chronology for the material lost from the tooth conceivably could be determined from the position of the neonatal ring on section of the tooth. This ring, an accentuation of incremental calcification rings laid down at known time intervals in the enamel and dentin, is a landmark which separates the prenatal and postnatal portion of the deciduous tooth (7, p. 82; 19).

Discussion

The data given here substantiate the feasibility of using deciduous teeth for monitoring the body burden of strontium-90 in growing children. Tooth and bones developing in the same biologic environment in utero accumulate strontium and calcium in the same ratio. Knowledge of the extent of prenatal and postnatal tooth formation and the degree of placental discrimination against strontium makes it possible to calculate fetal-bone and fetal-tooth concentrations of strontium-90 from concentrations measured in shed teeth.

A placental discrimination factor of approximately 2 for calcium against strontium-90 was found by Comar in animals (17). With a discrimination factor of 4 from diet to bone (20), the total discrimination factor from the mother's diet to the fetus might be expected to be 8. Kulp observed that the concentration of strontium-90 in fetal bone averaged only one-twelfth of that in the mother's diet (16). The average levels of strontium-90 in total skeletons of 54 stillborn infants of the

St. Louis area born from June 1959 through August 1960 was 1.2 μμc per gram of calcium. This is in agreement with the average concentration in fetal bone in areas of Western culture (16). Studies in St. Louis made by Consumers Union in November 1959 (21) revealed a level of 15.9 µµc of strontium-90 per gram of calcium in the total diet. United States Public Health Service total-diet studies show a level of 11.1 for Chicago (300 miles northeast of St. Louis) in May 1960 (22). If a mean of these dietary values is taken as representative of the diet in St. Louis, the ratio of level in diet to level in fetal bone in the St. Louis study is 9.

Calculations of concentrations of strontium-90 in fetal bone may be made from shed teeth as follows: Incisors are formed prenatally to the extent of 32 percent (Table 4). If the diet-to-tooth ratio is 1 to 12 prenatally and 1 to 4 postnatally, the concentration of strontium-90 added to the tooth postnatally would be 3 times that added prenatally if dietary strontium-90 remains constant. With these assumptions, the concentration of strontium-90 in the fetus can be found. If pre equals prenatal concentration of strontium-90 (in micromicrocuries per gram of calcium), post equals postnatal concentration, S equals concentration in shed tooth, and post equals 3 pre, then 0.32 pre + 0.68post = S, and pre = S/2.36.

The measured average level of strontium-90 in incisor teeth of children born in 1954 was $0.51~\mu\mu$ c per gram of calcium (23). From this value the strontium-90 concentration is estimated to have been $0.22~\mu\mu$ c in fetal bone, $2.6~\mu\mu$ c in the diet, and $0.65~\mu\mu$ c in newly formed (postnatal) bones and teeth. The average concentration for strontium-90 in teeth in children born in 1951 and 1952, when fallout was low, may represent strontium-90 appearing in teeth as a result of direct exchange with dietary strontium-90. If this concentration (0.18 $\mu\mu$ c per gram of cal-

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cium) is subtracted from 0.51 $\mu\mu$ c, the calculations yield 0.14, 1.7, and 0.42 μμc per gram of calcium for fetal bones and teeth, diet, and newly formed bone and teeth, respectively. These values may be compared to 0.12 µµc per gram of calcium reported by Libby (24) for fetal bones of children born in Chicago in 1954, and with the average dietary level of 2.0 µµc for areas of Western culture reported by Kulp for that year (16).

These calculations, based on analyses of shed teeth, are not unduly sensitive to errors in the assumptions. If 20 percent of the prenatally formed incisor is lost by abrasion, the estimated level in fetal bone is increased by only 5 percent. If the ratio of level in diet to level in fetal tooth is 1 to 10 rather than 1 to 12, the estimate is changed by approximately 13 percent.

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Since 1953, and particularly since 1957, many data have been accumulated on bone levels of strontium-90 in the fetus and in the child. The concentration of strontium-90 in newly formed bone can be estimated with ease from concurrent values for fetal bone (16). It is pertinent, therefore, to point out the special contributions which can be made to this body of knowledge by the early analysis of deciduous teeth. A large population can be sampled to provide a continuous record of strontium-90 absorption in man which will span the entire fallout period anywhere in the world. Thus, areas not previously studied can be made to yield a history of fallout, and gaps in chronological records elsewhere can be filled.

The experience in St. Louis suggests that tooth collection can be considerably simplified. This large collection was planned not only for a monitoring program but also for a much more extended investigation now being conducted by the Washington University School of Dentistry (25). The low concentrations of strontium-90 in the early years of fallout made it impossible to assess, before the initiation of this study, the size of the pools of teeth that would be required. At present it appears that much less extensive collections than ours could suffice to indicate the annual uptake of strontium-90. As the result of a modified analytic method reported by Butler (26), the requisite size of pools for analysis may be greatly reduced. This is encouraging, since a tooth-collection program on a large scale requires much organization. as is indicated by the description of the collecting activities.

On the basis of our experience, certain recommendations can be made concerning the size and composition of a deciduous-tooth collection suitable for the monitoring of strontium-90 absorption. Incisors are considered to be the type of tooth most useful for such a study. They can be collected most easily, for the program appears to have the greatest psychological appeal for the younger children, who are just beginning to lose their deciduous teeth. The incidence of caries is low, and a shorter period of time elapses between formation and shedding of the tooth than in the case of cuspids and molars.

Five thousand incisor teeth a year collected on a continuing basis from any area should, after 2 years, yield adequate data on absorption of strontium-90 approximately 7 years before the start of the collection, if the general characteristics of the St. Louis collection prevail. Where it is desirable to monitor an earlier fallout period, a larger number of deciduous teeth of all types should be collected.

Conclusions

- 1) Teeth and bones developing in the same biologic environment accumulate strontium-90 and calcium in the same ratio.
- 2) Collection of teeth can be accomplished on a large scale.
- 3) Analysis of deciduous teeth can provide information concerning strontium-90 deposition in bone.

- H. M. Kalckar, Nature 182, 283 (1958).
 The collection program was supported by the Leukemia Guild of Missouri and Illinois. The
 - Leukemia Guild of Missouri and Illinois. The analyses were made through grants from Consumers Union, Inc., and from the Cancer Research Committee, Washington University (American Cancer Society). I wish especially to thank Irving Michelson of Consumers Union for his help and encouragement.

 3. The Greater St. Louis Citizens' Committee for Nuclear Information is an educational group in the field of nuclear energy, composed of scientists and laymen.
- group in the field of nuclear energy, composed of scientists and laymen.

 4. The program was planned and executed with the guidance of an advisory group composed of the following members: Dean Leroy Boling and Drs. John T. Bird, Jr., John E. Gilster, and Harold L. Rosenthal, of the Washington University School of Dentistry; Dean Stephen P. Forrest and Drs. Donald E. Flieder and P. Forrest and Drs. Donald E. Flieder and Jules M. Snitzer, of the St. Louis University School of Dentistry; Drs. Eric Reiss and Alfred S. Schwartz, of the Washington University School of Medicine; Dr. Barry Commoner of the department of biology, Washington University; and Drs. E. S. Khalifah, Florence Rich, and P. G. Vierheller.

 I am particularly indebted to Dr. Florence Rich, who personally examined and classified all of the teeth.

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The International Indian Ocean Expedition

Oceanographers will make full-scale "laboratory" studies of ocean-atmosphere relationships.

John A. Knauss

Except for the glamor and excitement of working in far-away places, why are scientists particularly interested in studying the Indian Ocean? Many of the reasons are related to the monsoon. It is well known that the circulation in the Indian Ocean north of the equator changes markedly with the seasons. This change is particularly notable in the Arabian Sea, where there appears to be a complete reversal of the surface winds between January and July. This reversal is expected to have a marked effect on the biological production of the area. The regions of divergence and upwelling change with the seasons, and a given coastal area that, in one season, exhibits all of the characteristics of high productivity may be expecied to have low productivity the following season. Partly because of their obvious economic consequences, the problems connected with the natural productivity of various oceanic regions have received considerable study in recent years. The relationships between oceanic circulation and primary production are complex and not easy to separate. One of the fascinations of the Arabian Sea is that one can study a single region under widely varying conditions. The fact that the Arabian Sea apparently has large untapped fisheries and that massive fish mortalities have been reported from the area are additional stimuli to investigation.

The International Indian Ocean Expedition (IIOE) is the name given to a concerted effort by scientists to learn as much as possible about the Indian Ocean during the next few years. It will

include a series of oceanographic expeditions, in which at least 20 ships from a dozen countries will participate; the probable establishment of a marine taxonomic center somewhere in India; the operation of a laboratory ship for 2 years in the Indian Ocean for the purpose of studying marine biological problems; a series of geological and geophysical reconnaissance surveys of parts of the Indian Ocean; and an increase in the network of upper-air meteorological stations for studying the monsoon circulation.

Reasons for the Expedition

Although there may be some disagreement concerning our level of understanding of the steady-state relationship between the mean wind field and the major ocean currents, there is little argument concerning our understanding of the transient problem of the effect of a variable wind field on ocean currents. All are agreed that the problem is very poorly understood. Furthermore, it is a problem that is not amenable to investigation with experimental models, and our best means of attacking it would seem to be to study it in a region such as the Arabian Sea, where the winds blow steadily in one direction for several months and then reverse themselves. Unfortunately, the monsoon circulation is not that simple, but in the Arabian Sea the oceanographer probably comes closer than in any other oceanic area to achieving a "full-scale laboratory experiment" on this particular problem.

Successful laboratory experiments presuppose properly designed instru-

mentation, and it seems likely that a certain amount of preliminary work will have to be done in this field merely to define the scale of the phenomena we are attempting to observe. The Arabian Sea may be a fine oceanographic laboratory but it has one major drawback. The weather during the summer months can be very bad. For example, the average wind in the Arabian Sea during July is about 30 miles per hour.

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Although the equator is near the southern limit of the monsoon, it too is an interesting region to study. There is a seasonal reversal of winds along part of the equator and a reversal of surface currents. The most interesting problem, however, concerns the subsurface currents. Is there a swift, subsurface, eastward-flowing undercurrent in the Indian Ocean similar to that which has been observed in the Pacific and Atlantic oceans? There is as yet no completely satisfactory explanation for the Pacific and Atlantic undercurrents. However, because the other variables along the equator in the Indian Ocean appear to be different enough, it seems possible that a good knowledge of the subsurface currents of the Indian Ocean should help in evaluating the various conflicting explanations for the Pacific and Atlantic undercurrents.

The monsoon itself poses many interesting problems. The temporal and spatial relationships of the various events which, taken together, are referred to as the monsoon circulation have yet to be adequately described or explained. For instance, although the northern summer monsoon blows predominantly from the southwest at low levels, monsoon rains originate over southern China, apparently in response to upper tropospheric changes initiated southwest of India.

These are some of the problems that make scientists want to work in the Indian Ocean. Other prospective projects are the study of a western boundary current (such as the Gulf Stream) as it crosses the equator and the study of beach development under the reversal of strong, longshore currents. As our knowledge of the oceans increases, more and more often oceanographers ask themselves where they can go to observe a certain set of conditions in order to test a hypothesis. The Indian Ocean affords many opportunities for studies of this kind.

Many have claimed that the Indian Ocean is our least known ocean. In a

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science in which so much is unknown there are many contenders for this rather dubious honor (the central South Pacific and the equatorial Atlantic among others), but there is little question that the Indian Ocean ranks very high on the list. Much of the effort during the next few years will be concerned with gathering biological, physical, chemical, and geological information about the land, ocean, and atmosphere, in order to provide a better description of the Indian Ocean area.

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The International Indian Ocean Expedition was proposed at the initial meeting of the Special Committee for Oceanographic Research (SCOR) at Woods Hole, Massachusetts, 28 to 30 August 1958. At that time C. O'D. Iselin of the Woods Hole Oceanographic Institution was appointed convener of a small working group to consider exploration of the Indian Ocean. The Special Committee was established by the International Council of Scientific Unions (ICSU), and one of the reasons for its establishment was the fact that ICSU considered it important that international cooperation in field programs in oceanography be continued after the end of the IGY "on a broad basis and for a longer period."

The idea of a concerted effort in the Indian Ocean was further discussed, both informally and in formal sessions of SCOR, at the International Oceanographic Congress at United Nations Headquarters in New York, in September 1959. Shortly thereafter, SCOR asked Robert G. Snider to serve full time as Indian Ocean Coordinator. National committees were formed in many countries, including the United States.

In March 1960 the SCOR working group was reconstituted into three subcommittees under G. E. R. Deacon, director of the National Institute of Oceanography, England (1). Most members of the working group were able to meet in Copenhagen on 16 and 17 July 1960, at which time ideas and plans were exchanged and some matters of policy were decided. In the fall of 1960 the National Academy of Sciences Committee on Oceanography expanded its original panel for the International Indian Ocean Expedition to a series of five working groups (2). These groups were asked to prepare a program of

work to be done in the Indian Ocean—work to be concentrated in a 2-year period beginning about July 1962.

In at least two ways the International Indian Ocean Expedition is similar to the International Geophysical Year: it requires cooperation from scientists from different disciplines and from different countries, and it is growing in size and scope well beyond the conception of the original proposal (3).

The original idea of SCOR can be seen in the name "International Indian Ocean Expedition." To most people, an expedition is a rather well-defined enterprise. An oceanographic expedition usually consists of a ship or a group of ships working together in an area on a given set of problems. Georg Wüst, director emeritus of the Institut für Meereskunde, Kiel, proposed such an expedition at the New York meeting in 1959. He suggested that all ships work together, making identical observations and in this way collecting the necessary data for a first-order physical, chemical, biological, and geological description of the Indian Ocean (4). As Wüst noted, the plan was similar in concept to that of the famed Meteor Expedition in the South Atlantic, of 1925-27. However, as the plans of the various national committees take shape it becomes apparent that the opportunity to work in the Indian Ocean means different things to different scientists. The idea of making a concerted attack on the problems of the Indian Ocean has caught the imagination of many people, and Snider, in his most recent report, was able to outline the plans of 20 different countries. As in most thriving enterprises, the report was out of date as soon as it was released.

United States Plans

Like the International Geophysical Year, the International Indian Ocean Expedition has no specific beginning or end. There will probably be a peak of activity in 1963, but there has already been a marked increase in the amount of work being done in the Indian Ocean. The Soviet vessels Ob and Vitiaz have carried out investigations in the Indian Ocean, as have the Atlantis, the Vema, and the Argo of the Woods Hole Oceanographic Institution, the Lamont Geological Laboratory, and the Scripps Institution of Oceanography, respectively. Oceanographic vessels from

France and Japan have worked in the area recently, and there has been an increase in the oceanographic activities in several countries that border on the Indian Ocean, particularly in Australia.

The following are examples of projects planned as part of the U.S. National Program for the Expedition in the next 2 or 3 years.

- 1) The Woods Hole Oceanographic Institution is planning a program, in cooperation with the National Institute of Oceanography, England, to study the changing circulation pattern in the Arabian Sea during the two monsoon seasons. This work will begin in late 1962 or early 1963 and will include considerable work on the biological cycle related to these changing conditions.
- 2) The U.S. Coast and Geodetic Survey, in cooperation with the Committee on Mean Sea Level of the International Union of Geodesy and Geophysics, is planning to install 28 special tide gauges around the Indian Ocean, primarily to observe seasonal changes in sea level. It seems likely that seasonal changes are greater in parts of the Indian Ocean than anywhere else in the world.
- 3) The Scripps Institution of Oceanography of the University of California and the Narragansett Marine Laboratory of the University of Rhode Island are planning a joint expedition to the Indian Ocean, beginning in July 1962, to study the circulation in the vicinity of the equator during the two monsoon seasons. There will be two 3-month expeditions. During the first, the Scripps vessel will work in cooperation with one Australian ship. During the second, the work will be done in cooperation with several Japanese ships, with the National Institute of Oceanography, and perhaps with other groups.
- 4) It is expected that a "biological ship" will be stationed in the Indian Ocean for 2 years. This ship will be operated by the Woods Hole Oceanographic Institution and will be under the directorship of J. H. Ryther. It will serve as a kind of national facility for biologists from various parts of the country who would like to participate in the International Indian Ocean Expedition.

The U.S. Biological Program will consist of 2 years of operations in the western sector of the Indian Ocean, between the tips of India and Africa, during the calendar years 1963 and 1964. Approximately half the time will

be spent in making a series of meridional (north-south) sections between the land and the subtropical convergence (40°S) for studies of the systematics, distribution, and abundance of marine life in relation to water masses, current systems, and the monsoonal circulation. There will be sampling of all forms of life, from microorganisms to the large pelagic fishes and from the benthos to the surface flora and fauna. The other half of the ship's operations will consist of intensive ecological or physiological investigations of the flora and fauna in regions of particular interest (the Arabian Sea, the equatorial region, the Bay of Bengal, and so on) and of such biological phenomena as plankton blooms and red water, fish mortalities, and bioluminescence. During the same period, investigations of coastal and inshore waters, of islands, and of reefs are also planned, with landing of shore parties at such island locations as the Maldives, the Laccadives, the Chagos, the Seychelles, Mauritius, and Madagascar. Biologists interested in this program should write directly to John H. Ryther, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

5) It is planned to establish, under UNESCO sponsorship, a marine taxonomic center somewhere in India. This center will serve as a preliminary sorting center for collections made in the Indian Ocean and at the same time will provide India with a reference collection of marine organisms from the area.

6) As part of an intensive study of the monsoon circulation, it is hoped to substantially increase the number of stations in the area that are capable of measuring winds at high levels. As part of this program, the United States hopes to man two weather ships stationed on the equator for a 2-year period. Besides providing meteorological observations, the two ships will be used for making intensive physical, chemical, and biological observations.

7) The IIOE provides an excellent opportunity for making more accurate calculations of the energy flux between the ocean and the atmosphere. Such observations and calculations can be made in several more or less independent ways, and it is hoped that four different techniques may be used for intercomparison.

8) Scripps, Woods Hole, Lamont, and the U.S. Coast and Geodetic Survey all expect to conduct reconnaissance-type geological-geophysical cruises in the Indian Ocean between now and 1964. (Lamont and Scripps have each had one such cruise to the Indian Ocean in the last 2 years.) Their programs will include gravity, magnetic, and bathymetric observations while the vessels are under way and coring, heat-flow studies, bottom photography, and seismic refraction observations while they are on station. Generally speaking, Lamont will work in the southern Indian Ocean, Scripps in the west-central region, and Woods Hole in the west Indian Ocean and the Arabian Sea.

9) The newly established National Oceanographic Data Center in Washington, D.C., will process much of the data from the expedition and will assist in the dissemination of data reports to interested persons in the United States and other countries.

Foreign-Policy Implications

Presidents Eisenhower and Kennedy have both endorsed the United States' participation in the International Indian Ocean Expedition. Although presumably the President of the United States is gratified whenever this country makes progress in science, it is probable that presidential endorsement of the IIOE signifies concern not so much with verification of theories of the equatorial circulation as with matters such as cooperation between oceanographic vessels of different nations, the development of oceanography in many of the countries bordering on the Indian Ocean, and the development of new fisheries industries in these countries from local programs growing out of the International Indian Ocean Expedi-

Whether science should be an instrument of foreign policy is no longer in question, if it ever was; the question now is how and under what circumstances it can be. The one point that does seem clear is that a scientific program, to be an effective instrument of foreign policy, must first of all be good science. A scientific idea or program that is pushed primarily for political reasons will ultimately fail, not only as science but as effective politics as well. It is important, therefore, that the International Indian Ocean Expedition be

justified on the basis of its scientific program. If it can be, and if the various programs are carried out successfully, then there is reason to hope that it will also be effective in furthering international cooperation in science, assisting in the growth of science in underdeveloped countries, and attaining other objectives.

Scientists who wish to learn more details about any part of the U.S. program should address their queries to Robert G. Snider, Indian Ocean Coordinator, 30 East 40 Street, New York 16, New York, or to any of the chairmen or members of the various working groups. Questions about the programs of other countries should be addressed to Mr. Snider.

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References and Notes

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(Geographia Institute, Moscow).

2. Members and observers of the NAS-NRC Committee on Oceanography IIOE Panel and working groups. Panel on Indian Ocean Expedition: Columbus O'D. Iselin (chairman), R. D. Fusselman, H. Arnold Karo, John Lyman, Arthur E. Maxwell, Roger Revelle, Joseph L. Worzel. Working Group on Biology: John H. Ryther (chairman), K. Banse, Alan W. H. Be, Howard Eckles, David Keck, David McGill, John A. McGowan, Dixie Lee Ray. Working Group on Geology, Geophysics, and Bathymetry: Robert L. Fisher (chairman), Preston E. Cloud, Charles L. Drake, Earl E. Hays, Bruce C. Heezen, Arthur E. Maxwell, George C. Shor, Jr., Harris B. Stewart, Jr. Working Group on Meteorology: Robert Fleagle (chairman), Jacob Bjerknes, Alfred K. Blackadar, Andrew Bunker, Earl Droessler, Donald Portman, Colin Ramage, Morris Tepper, Jack C. Thompson.

Morris Tepper, Jack C. Thompson.

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Science and the News

Brown vs. Baker: The Supreme Court Finds Itself in an Awkward Situation

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Some Monday morning within the next few months, and more probably within the next few weeks, the Supreme Court will hand down its decision in the case of Baker vs. Carr. It is generally expected that the court will favor Baker, and, if so, the decision will be the most significant since Brown vs. Board of Education. Brown argued that segregation in the public schools was unconstitutional. Baker is arguing that the same "equal protection" clause of the 14th Amendment that makes school segregation unconstitutional should also be used to protect citizens in one part of a state from having their voting rights grossly diluted by citizens in another part of the state. In the case at hand, voters in some parts of Tennessee cast ballots that are worth 20 times as much as the ballots cast by voters in other parts of the state; statewide, one-third of the voters elect twothirds of each house of the state legislature. Since the Tennessee situation is fairly typical of what exists in most states, a decision favoring Baker is expected to lead to a change in the balance of political power not only in Tennessee, but eventually in most other states. The readjustment will take a good deal of power away from rural voters and give it to city voters.

The rapid development of science and technology is close to the heart of the case. With the growth of modern technology the country has changed from a predominantly rural to a predominantly urban society. Problems of what is called "malapportionment" may have arisen in any case, but without the new technology and the development of concentrated population centers it fostered, the problem could not have been so widespread, and certainly it could not have been so gross. A good legal case can be made that any obviously unfair apportionment of seats

in the state legislatures violates the constitutional rights of the people whose voting rights are diluted. But, for reasons that will be gone into later, it is most unlikely that the Supreme Court would involve itself in the question if the rise of the new technology and the resulting urbanized society had not made the problem a gross and widespread one. And it is doubtful that the court would be seriously considering intervening, even to correct gross and widespread malapportionment, if not for the fact that the advances in technology that helped increase the extent of the malapportionment problem also helped create problems of government that the malapportioned legislatures seem unable to deal with.

Not too surprisingly, the rural legislators have not been anxious to reapportion, that is, to vote themselves out of power. The worse the situation grows the more the rural legislators stand to lose and the less likely they are to reapportion. In Tennessee the state constitution says that a census must be taken and a reapportionment made every 10 years. The last time this was done was in 1901, which must have been a good year for reapportionment since a number of cases that have been brought to court in other states also look back to 1901 for the last reapportionment. The record for nonreapportionment goes to Vermont, which apportioned the state in 1793 and has let things slide ever since. As a result one rural vote in Vermont is worth as much as 600 city votes. Burlington (pop. 33,000) has one seat in the state senate; so does Victory (pop. 48).

The Baker case now before the Supreme Court is the sort that makes laymen suspect that much of the law is some kind of mad conspiracy among lawyers to confuse non-lawyers. From a non-lawyer's viewpoint, citizen Baker and his fellow city-dwelling Tennesseeans should have no trouble winning their case. The Tennessee legislature is, after all, obviously violating the state

constitution in order to deprive some. indeed most, of its citizens of their proper voice in the state government. Also, Article IV of the federal constitution guarantees to every state a republican form of government, and Baker would seem to have a good chance of persuading the Supreme Court that a situation in which one-third of the state elects two-thirds of the legislators was not what the founding fathers had in mind when they wrote this guarantee into the constitution. From a lawver's point of view, though, neither of these things has much to do with the case. Indeed it was the lawyers for Tennessee who, much to the discomfort of Baker's lawyers, kept insisting that the city folks were demanding a republican form of government, and the Justice Department, which came before the court to support Baker, was afraid the city folk had lessened their chances of winning the case by putting too much emphasis on the fact that the present apportionment violates the state constitution.

Lawyer's View

From a lawyer's point of view the violation of the state constitution is not the business of the federal courts. It is up to the state courts to interpret the state constitution. A couple of years ago the city dwellers asked the state courts to instruct the legislature to obey the state constitution. One state court thought this reasonable, but the state supreme court thought it unreasonable because to write such instructions would make the present apportionment unconstitutional, which, it reasoned, would leave the state with no legislature to make up a new apportionment, which, the court reasoned further, "would lead to the destruction of the state itself." The city dwellers found this reasoning specious and tried to tell the U.S. Supreme Court so, but the Supreme Court would have none of it and dismissed the case without a formal hearing, as it has done with all malapportionment cases since Colgrove vs. Green in 1946. when the majority (not really a majority, as will be seen) ruled that the courts "ought not to enter this political thicket." The city dwellers went back to Tennessee and filed a new suit, this time in the federal courts, charging their rights under the federal constitution were being violated. When the Supreme Court finally decided to take the case, a suspicion arose that it was getting ready to change its mind, since it strained even a lawyer's imagination to find any important differences between the latest case and all the dozen or so previous ones that had been turned down peremptorily on the precedent of the Colgrove opinion.

The Colgrove case happened to involve congressional rather than state legislature malapportionment. In Illinois in 1946, when the case came up, the largest congressional district had nine times as many people as the smallest. Technically, the case, like other malapportionment cases, was not a case at "law" but at "equity." In informal terms, a law case is one where the courts have only to decide who is right; an equity case is one where the courts have to decide not only who is right, but go on to say what must be done. If Jones sues Smith a law suit will decide whether he is right and can collect damages. If the local authorities then refuse to help Jones collect his damages, you can have an equity case, where the courts have to decide not whether these local authorities have been behaving improperly, but, if so, to tell them what they must do. The courts have to decide law cases, but in equity cases they can decline to get involved. In the Colgrove case, and in all reapportionment cases since then, the courts have declined to get involved, principally on the grounds that legislative apportionment, like the guarantee of a republican form of government, is a political question, and that the courts should not get involved in deciding just what fair apportionment requires, or what constitutes a republican form of government. The court has taken the view that these are questions for Congress to decide.

In the Colgrove case the court decided not to intervene, but only three of the seven justices participating in the decision went along with the view that the court ought to refuse, as a matter of principle, to get involved in what Justice Frankfurter called "this political thicket." Three other justices took the opposite view, and voted to intervene. The deciding vote was cast by Rutledge, who voted against intervening, but on the ground that it was too close to the election for the court to prescribe an effective remedy, not on the grounds that the courts ought to refuse to take up such cases.

The Illinois legislature obviously interpreted this to mean that there would be a majority for intervention if a new suit were filed after the election in

plenty of time for the court to work out a remedy before the next election. The legislature reapportioned the congressional districts the next year. But the Supreme Court itself has been acting as if a majority had voted in favor of nonintervention as a general principle, for it adopted the practice of simply citing Colgrove as authority for peremptorily turning down later reapportionment cases. The lawyers for Baker have tried to encourage the court to change its mind on intervening in apportionment cases by arguing that it never made its mind up, which is easy to argue if Colgrove is considered alone, but hard to argue if you look at what the court has done with all reapportionment cases since Colgrove.

What it all comes down to is that for all practical purposes the court has made up its mind, but that it had backed into the position, which will make it a bit easier for the court, if it chooses, to back out again. As a further practical matter, it will not be necessary for laymen to grasp all the fine points of the arguments to understand what the court is doing, since the decision, like other major decisions of the Supreme Court since George Washington's time, will be more understandable in terms of practical considerations than in terms of the fine points of law.

Earlier this year, the court did intervene in a redistricting case when the Alabama legislature changed the boundaries of Tuskegee from a square into a peculiar 28-sided figure which by coincidence happened to leave every Negro voter out of the city. The case was closely similar to the general run of reapportionment cases in that it did not deny the Negroes the right to vote, which would have been obviously unconstitutional, it only arranged things so that the right to vote would not be very valuable. This, of course, is essentially what is happening to the urban residents in Tennessee and so many other states.

The court unanimously ruled the Tuskegeo gerrymander unconstitutional. It drew a number of distinctions to separate the case from the malapportionment cases, but as a practical matter it had entered the "political thicket" of reapportionment and gerrymandering, and for a very practical reason which did not appear in the court's written opinion: Negroes have been making painfully slow but, to segregationists, painfully clear, advances in asserting their voting rights in the South. If the

Supreme Court refused to intervene at Tuskegee most of these gains would go down the drain, for segregationists would feel they had a free hand to keep Negroes from getting any real voice in the government so long as they did not actually prevent Negroes from casting ballots.

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The Tennessee case is more difficult. Congress had made it comparatively easy for the Supreme Court to intervene in cases involving Negroes by passing a Civil Rights bill in 1957 with the plain purpose of making it easier for Negroes to get help through the courts. This did not really give the courts any more power than they already had. Its importance was that it indicated congressional approval for the federal courts to involve themselves in questions of discrimination in voting rights within the various states. But there was nothing to indicate that Congress was encouraging court intervention in the general run of malapportionment cases. So the problem for the Supreme Court is that if it intervenes in the Tennessee case it will be expanding its jurisdiction to an area that has so far been left to Congress, and it will be using (some will say abusing) the power of the Supreme Court to tell the states how to run their internal affairs. On the other side, if it refuses to intervene it will be leaving the city voters in many states with no way to assert their constitutional rights, since the legislatures are obviously not going to reform themselves; since most state courts, following the Supreme Court, refuse to intervene; and since there are enough Congressmen with a vested interest in malapportionment to make it nearly impossible for a bill encouraging the courts to act to become law.

This would not only deprive the city voters of an abstract right, but would leave the state legislatures permanently in the hands of the minority of rural voters, who have no particular interest in the educational, air- and water-pollution, and other problems that are most severe in the cities. The Court will also be putting itself in an awkward position for dealing with new segregationist malapportionment cases in the South, sure to arise, which may be harder to differentiate from the general run of such cases than was the Tuskegee gerrymander.

If the court finds for Baker, it will be deep in Frankfurter's "political thicket." New cases will come up where it will not be so clear as it is in

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Tennessee that the legislature has no reasonable basis for refusing to reapportion, only a desire to keep a grossly disproportionate share of political power in the hands of the people who already hold it. If it refuses Baker's appeal, it will be dealing a hard blow to the efforts to find a remedy for what nearly everyone, even those who think the court should not intervene, feels is an increasingly unfair and unhealthy situation, and one that seems most unlikely to yield to any less awkward solution than court intervention.

The case has now been argued twice before the Supreme Court. It came up last spring, but the court came to no decision, and instead ordered another 3 hours of oral argument on the opening day of this year's session. Nothing much new came up in the re-argument, and it is supposed that the court ordered the re-argument primarily to give itself more time to consider the decision. So the justices have now had over 6 months to consider their decision, and it is a measure of the difficulty of the case that lawyers feel it is quite appropriate that the court should mull over the problem awhile.

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When the decision comes, it will be based on a balacing of practical consequences, rather than a balancing of the fine points of the law. The suspicion here is that the court is going to intervene.—H.M.

Cooperation in Space: Soviet Scientists and Politicians Appear To Have Different Views

Western scientists have generally noted that their Soviet counterparts eagerly welcome East-West scientific cooperation. One of the areas, however, where virtually none has taken place is in the exploration and use of space. Last week there were indications that the exclusion of space from East-West cooperation is the subject of conflict between some Soviet scientists and their political chiefs.

The indications showed up in the chronology of events between acceptance and last-minute rejection of an American invitation for the Soviet Union to join in a first step toward international cooperation in satellite weather forecasting. The acceptance was the first departure from the U.S.S.R.'s rigid policy of rejecting U.S. attempts to de-

velop cooperative space efforts. As such, it stirred considerable interest in the Administration, which, from its first days, has been seeking to interest the Soviets in joint space undertakings.

The first positive response to these U.S. efforts was the Soviet acceptance of an invitation to participate in the International Meteorological Satellite Workshop. This conference, sponsored by the U.S. Weather Bureau and the National Aeronautics and Space Administration, was held in Washington from 13 to 22 November. Its purpose was to familiarize other nations with the weather forecasting techniques derived from the American Tiros satellite system.

An invitation to the conference was extended in August to Andrei A. Zolotukhin, director of the main administration of the Soviet Hydro-Meteorological Service, by his American counterpart, Francis W. Reichelderfer, head of the Weather Bureau. On 20 October the Soviet official cabled that the meeting would be attended by two Soviet representatives, Victor A. Bugayev, director of the Central Forecasting Institute, and Sergey N. Losyakov, of the State Committee on Radio Electronics. The Soviet government applied for visas, and they were promptly issued.

The Polish Academy of Sciences responded, in a letter dated 31 August, that it would probably send representatives; the Czech Academy of Sciences cabled an acceptance on 7 November, less than a week before the conference opened. Neither the Czechs nor the Poles, however, applied for visas, and they showed no further interest in the conference.

There was no further communication from the Soviets until the day after the opening of the conference, when Reichelderfer was notified in a cable from Zoiotukhin, "our representatives unable to attend. . . ." The cable requested "relevant papers if possible," but offered no explanation of the last-minute rejection of the invitation.

The incident is a provocative one for Kremlinologists seeking to divine the relationship between Soviet scientific and political circles. Barring bureaucratic muddle as an explanation—perhaps excluded too frequently in seeking explanations of mysterious occurrences in the Soviet Union—the incident conforms to Western observations that Soviet scientists and politicians appear to be at odds on the benefits to

be derived from an East-West swap of space technology.

It has been reported that in private talks Soviet scientists have revealed an interest in cooperating in the establishment of a world-wide weather satellite system. On the political and propaganda fronts, however, the Soviet Union has remained rigidly aloof from joint space efforts and has denounced the weather satellite program as a screen for military reconnaissance. NASA and the Weather Bureau have strictly isolated their satellite efforts from the Air Force's Samos and Midas reconnaissance programs. But in the Soviet view of things, the oft-stated distinction between the United States' civilian and military programs is nothing but a transparent propaganda device. In denouncing the weather satellite program, the Soviets have made it plain that they regard it as nothing more than a successor to the U-2, which evokes in them memories of the most successful U.S. effort to get a look at their carefully guarded space establishment.

Although the most benign intentions have gone into the development of the Tiros weather satellite system, in design the satellite is a close cousin of the military reconnaissance satellites, and it merits no distinction in the view of Soviet military planners. These planners have made it clear that they see no Soviet purpose served by cooperation in the development of a device that can defy their efforts at secrecy.

The Weather Bureau says that it will respond to the Soviet request for the conference's scientific papers. In the existing Cold War chill, however, the traffic is likely to remain one way and limited, despite indications that some Soviet scientists do not share their leaders' views of who has most to gain from East-West cooperation in space.

—D.S.G.

Educational Television: Setbacks in New York City and Boston

Adversity is no stranger to the promoters of educational television, but in recent weeks they have suffered two especially hard and unexpected blows.

The first occurred on 13 October, when fire destroyed the studios of WGBH-TV, the Boston educational station which had become a major link in a growing, nationwide educational network

The second blow, delivered last week,

inflicted a reversal as unanticipated as the fire, but potentially more damaging. This came in the form of an order from the U.S. Court of Appeals in Washington, blocking the sale of channel 13, occupied by WNTA-TV in Newark, N.J., to a New York ETV organization.

The establishment of channel 13 as an educational outlet has come to be regarded as the route for a major breakthrough in ETV's long and difficult struggle for access to major audiences. Though it long has had the good wishes of the Federal Communications Commission, ETV has found little space available on the very high frequency band, which is the only band that can be received on virtually all the nation's TV sets. The ultra-high frequency band, for which few sets are equipped, stands open for ETV's expansion, but ETV groups have been understandably reluctant to broadcast on a band which reaches only a tiny audience. The importance of channel 13 for ETV lay in the fact that it is on the VHF band, in the heart of the nation's most populous reception area.

The court action blocking the sale was in response to a petition from Governor Robert B. Meyner, of New Jersey, who argued that the sale to a New York group would deprive New Jersey of its sole commercial television outlet. In granting his request for a stay of the sale, the court noted that the FCC has approved the sale without giving New Jersey the opportunity for a hearing. The ruling, by a three-judge panel of the nine-member court, came after a 30-minute hearing and was wholly unexpected by attorneys for the FCC and the ETV group. The owners of the station, meanwhile, have announced that if the sale is not carried through by 27 November, the expiration date of the sales contract, they will retain ownership. They have indicated that the economic reverses which made the sale attractive to them may be ended by a contract for broadcasting baseball games. At the same time, the FCC asked the court to reconsider its decision, but it is extremely unlikely that a new ruling will be forthcoming before the 27th. Some observers think the channel 13 case is now en route to becoming a landmark fiasco in ETV.

Whether or not it is, it is well larded with some extreme ironies. Legal experts, though their fingers were singed by the unexpected court ruling, contend that on the merits the FCC was correct

in authorizing the sale to an educational group over the objections of Governor Meyner and without a hearing. It is within the FCC's discretion to grant a transfer of a station without a hearing if it concludes there is no substantial question of fact involved. The course it chose reflected the friendly atmosphere which has been generated for ETV since Newton Minow became FCC chairman. The channel 13 case has been of especial interest to Minow, and it is reported that he took special pains to ease the way for the sale to the ETV organization. As a result, however, the case was brought up against a procedural block which now threatens to negate the sale.

The source of Meyner's persistent opposition to the sale constitutes a considerable mystery. WNTA, the present occupant of the channel, was never noted for rendering public service to the State of New Jersey, and if its present owners succeed in landing a baseball contract, that tradition would probably continue. The ETV group, on the other hand, has pledged itself to air the state's public affairs, and on the basis of ETV's performance elsewhere, the pledge deserves respect.

In Boston, meanwhile, the task of restoring the burned-out WGBH is receiving considerable public support. The station's transmitter was not affected by the fire, and commercial stations in the area have been lending WGBH studio facilities. Public contributions for new studios have passed \$300,000. The goal is \$1.5 million, and the prospects are bright, which cannot be said, at present, for bringing ETV to New York.—D.S.G.

Project West Ford: Cause of Failure Still Unknown

The status and future of Project West Ford were beset by uncertainty this week, a month after the initial attempt to establish an experimental wire filament belt in space. A spokesman at the Lincoln Laboratory said a second attempt would not be made until efforts were completed to account for the failure. It appeared that this would not be accomplished quickly.

The filament belt, intended for tests on jam-proof communications, was to have been formed by 350 million hair-like copper wires discharged from a 15- by 50-centimeter canister. On 21 October the canister was carried aloft

on a Midas satellite, but there has been no evidence that it discharged the filaments. The first indication that the canister itself had separated from the satellite came on 3 November, in a 75-second radar image. Efforts to pick up the image again have been unsuccessful, and there is some doubt now about whether it actually was created by the canister.

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The controversy over whether the project would interfere with radio and optical astronomy has led to considerable caution in the decision on when to attempt another shot. The Lincoln Laboratory wants to be as certain as possible that the second attempt will not be followed by a sudden blossoming of filaments from the first canister. —D.S.G.

Mental Retardation: President's Panel Is Moving Quickly

The Washington landscape is dotted with the remnants of boards and panels summoned to special tasks and then quickly forgotten. It appeared unlikely last week that such would be the fate of the special panel on mental retardation established in mid-October by President Kennedy.

The President took special pains at the time he announced establishment of the panel to emphasize his personal interest. Last week, Leonard Mayo, head of the panel, asked each member to consider "What you would do if you had the opportunity, with unlimited resources at your disposal, to create and build a comprehensive program of research, care and education for the mentally retarded."

At the same time, Mayo appointed Edward Davens, deputy commissioner of the Maryland State Department of Public Health, to head the panel's research task force. He also appointed William Hurder, associate director for mental health, of the Southern Regional Education Board, as chairman of a task force on services. The two panels will meet at the Department of Health, Education, and Welfare on 8 December.

Recently appointed as a consultant to the panel was the President's sister, Mrs. R. Sargent Shriver, Jr. Her presence provides the panel quick access to the President and enhances the prospects of smooth relations with various federal agencies that may be of assistance to the panel.—D.S.G.

Announcements

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Designs for an unmanned acoustics research vessel have been completed by the U.S. Naval Ordnance Laboratory. The 350-foot vessel, to be called SPAR (Seagoing Platform for Acoustics Research), is essentially a 16-foot diameter steel tube that will be used to measure the speed and intensity of underwater sound transmission down to 300-foot depths. During operation, a tending ship remotely floods the stern of the vessel, making it swing down and settle in a vertical position with only 50 feet protruding above the surface. Underwater listening devices, thermometers, pressure gages, and instruments for determining the amount of salt in the surrounding sea will be attached on the exterior hull, while operating machinery and additional instruments will be housed in the upper section. The vessel will relay research data to the tending. ship by electrical cable, and will receive underwater sonar signals and abovewater radar signals from a transmitting

SPAR, designed for use in the Atlantic, is a counterpart to another vessel being developed for use in the Pacific by the Office of Naval Research, in cooperation with Scripps Institution of Oceanography. However, the Pacific Vessel, called FLIP (Floating Instrument Platform), will be manned and will be allowed to drift with the wind and currents.

A Soviet study of metallography and the physics of metals, translated by the U.S. Air Force Technical Information Center, claims that radioactive tracer methods have enabled Soviet researchers to compile "a large body of experimental material" on various problems in the field. A report on the results of these studies, according to the editors, was submitted in 1955 to the Geneva conference on the peaceful uses of atomic energy.

The two-volume publication includes the proceedings of a symposium sponsored by the U.S.S.R.'s Institute of Metaliography and the Physics of Metals. (Office of Technical Services, Department of Commerce, Washington 25, D.C. Order No. 61-11156. \$7)

The National Institutes of Health has formed a **lipid advisory committee** to stimulate increased production and quality of lipid research compounds manufactured by private laboratories. The action follows the National Advisory Heart Council's recognition of growing needs for pure compounds in kilogram quantities, pure radioactive compounds of high specific activity, and reference standards for gas chromatography and other laboratory purposes. Through contracts with private laboratories, the committee hopes to provide investigators with lipid research materials not presently available in sufficient quantity at reasonable prices. The eventual goal is to put commercial production of the compounds on a selfsustaining basis.

Antarctic research proposals for the 1962-63 field season are now being accepted by the National Science Foundation. Proposals should be for aurora and airglow, biology and medicine, cosmic rays, geodesy and cartography, geology, geomagnetism, glaciology, gravity, ionospheric physics, meteorology, oceanography, seismology, or other research pertinent to Antarctica. Staff members of the foundation's Office of Antarctic Programs are available for informal discussions of proposals prior to their final submission. Deadline: 15 February 1962. (Director, NSF, Office of Antarctic Programs, Washington 25, D.C.)

The Asia Foundation's Books for Asian Students program needs scientific and technical books or journals (in runs of 5 years or more) published after 1945. Books should be in good condition, and on the university, college, or secondary level. The foundation will pay shipping costs from the donor to San Francisco, and thence to Asia. (Books for Asian Students, 21 Drumm St., San Francisco 11)

A heart-lung laboratory to study space-flight stress in man has been established at Wright-Patterson Air Force Base. The laboratory, founded by the Indiana University Foundation under a grant from the U.S. Air Force Systems Command, will investigate effects of prolonged accelerations, heat, altitude, vibration, impact, and combinations of these stresses on both human and animal subjects. The new unit will also sponsor seminars in cardiopulmonary physiology to exchange ideas with other leaders in the field. (S. Carroll High, Jr., Aeronautical Systems Division, Wright-Patterson AFB, Ohio)

Courses

The U.S. Public Health Service will conduct the following related courses during 1962 at the Robert A. Taft Sanitary Engineering Center:

Medical aspects of radiological health; 8 to 19 January.

Basic radiological health; 15 to 26 January. This course will be repeated at the center from 23 April to 4 May; at the Southwestern Radiological Health Laboratory in Las Vegas from 26 February to 9 March; and at the Radiological Health Laboratory in Rockville, Md., from 7 to 18 May.

Radioactive pollutants in air; 29 January to 2 February.

Radioactive pollutants in water; 5 to 9 February.

Radionuclides in water; 12 to 16 February.

Participants in the air and water courses should have completed the basic radiological health course, or equivalent training, prior to enrollment. (Chief, Training Program, Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26)

A graduate program leading to a Master of Science degree in hospital pharmacy administration has been established at the Brooklyn College of Pharmacy in New York. Courses will be given during the evening hours so that internship training or regular hospital employment may run concurrently with academic instruction. (Arthur G. Zupko, Brooklyn College of Pharmacy, 600 Lafayette Ave., Brooklyn 16)

Chemists, metallurgists, physicists, production supervisors, and quality control engineers are invited to attend the 41st Norelco X-ray Analytical School, to be held in New York from 5 to 9 February 1962. The course, sponsored by Norelco Instruments, will cover x-ray diffraction, diffractometry, and spectrography. There is no charge for attendance, but capacity is limited. (Norelco Instruments, 750 S. Fulton Ave., Mount Vernon, N.Y.)

Grants, Fellowships, and Awards

An international award in plastics science and engineering has been established by the Society of Plastics Engineers to stimulate fundamental contributions and acknowledge outstanding achievements in the field. The \$1000

award will be presented annually "without regard to sex, age, nationality, or membership in the SPE." The initial presentation will be made during the society's 18th annual technical conference, to be held in Pittsburgh from 30 January to 2 February 1962. (SPE, 65 Prospect St., Stamford, Conn.)

Grants-in-aid of health service projects are available to public and nonprofit agencies through the U.S. Public Health Service. Types of projects eligible for aid include home nursing services for the chronically ill and aged, improvements in the care given to patients in nursing homes, and programs for making a variety of therapeutic and other services available to patients in their own homes. Preference will be given to those projects that will be partially financed by the applicants, and to those that are likely to be continued after federal aid is withdrawn. (Grants Management Branch, Bureau of State Services, PHS, Washington 25, D.C.)

Teaching and research assistantships, or 3-year graduate fellowships in statistics, are available for the 1962– 63 academic year. (R. A. Bradley, Department of Statistics, Florida State University, Tallahassee)

Applications are now being accepted for the two Turtox scholarships in botany, zoology, or biology for the 1962–63 academic year. The \$5000 awards, established by General Biological Supply House, Inc., will be based upon the applicant's prospects as a teacher and research scholar. Applicants must be currently, or have been, enrolled in a graduate school and studying for a doctoral degree in one of these fields. Deadline: I February 1962. (Frank A. Brown, Jr., Department of Biological Sciences, Northwestern University, Evanston, Ill.)

Graduates in biology, chemistry, engineering, and physics are invited to apply for U.S. Atomic Energy Commission fellowships in health physics. Appointees perform 9 months of academic work at one of eight selected universities, followed by 3 months of field work at an AEC national laboratory. Stipend is \$2500 for 12 months, plus tuition, fees, and allowances. Deadline: 1 February 1962. (Health Physics Fellowship Office, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.)

Scientists in the News

Recently elected foreign members of the Royal Society of London:

Solomon Lefschetz, director of the Martin Company's center for differential equations in Baltimore, Md.

Elmer V. McCollum, emeritus professor of biochemistry at Johns Hopkins.

Olaf Holtedahl, emeritus professor of geology at the University of Oslo (Norway).

A. N. Nesmeyanov, former president of the U.S.S.R. Academy of Sciences in Moscow.

Ralph E. Knutti, associate director for extramural programs at the National Institute of Arthritis and Metabolic Diseases, has been appointed director of the National Heart Institute. He succeeds James Watt, recently named chief of the Public Health Service's division of international health.

Herbert L. Haller, assistant to the administrator of the Agricultural Research Service in the U.S. Department of Agriculture, will receive the 1961 Charles F. Spencer award for "outstanding achievement in the field of agricultural and food chemistry." The \$1000 award, established by the late founder of Spencer Chemical Company in Kansas City, Missouri, is administered by the American Chemical Society's Kansas City section.

A. A. Dougal, of the University of Illinois, has been named professor of electrical engineering at the University of Texas.

Reavis Cox, of the University of Pennsylvania; George Katona, of the University of Michigan; and the late Charles C. Parlin, former manager of the American Marketing Association, are the recipients of the association's 1961 Paul D. Converse awards for "contributions to the advancement of science in marketing."

David P. Bloch, of Columbia University, has been appointed associate professor of botany at the University of Texas.

Milton M. Klein, plasma physicist and former consultant to the General Electric Company's missile and space vehicle department in Philadelphia, Pa., has joined the staff of the Geophysics Corporation of America.

G. C. Dacey, director of Bell Telephone Laboratories' solid state electronics research laboratory, has been appointed vice president of research for Sandia Corporation in Albuquerque, New Mexico.

G. S. Fraenkel, professor of entomology at the University of Illinois, recently became the third American to be elected honorary fellow of the Royal Entomological Society of London.

John A. Pople, of the National Physical Laboratory in Teddington, England, has been named Ford visiting professor of chemistry in Carnegie Institute of Technology's college of engineering and science.

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Robert E. Snodgrass, honorary research associate of the Smithsonian Institution, has received the 1961 Leidy medal for his work in the morphology and evolution of insects. The award is presented triennially by the Academy of Natural Sciences.

F. S. Dainton, of the University of Leeds (England), has been named George Fisher Baker lecturer in chemistry at Cornell University for the 1961 fall term.

Morton I. Goldman, former nuclear installations consultant for the Public Health Service's division of radiological health, has joined Nuclear Utility Services, Washington, D.C.

Robert Galambos, chief of neurophysiology at Walter Reed Army Medical Center, has been appointed Eugene Higgins professor of psychology at Yale University.

William M. Upholt, former regional representative for the U.S. Public Health Service's Communicable Disease Center in San Francisco, has been appointed chief of the research grants section in the service's office of resource development for environmental health, Washington, D.C.

The Helen Hay Whitney Foundation in New York has posthumously honored the late William T. Astbury, of the University of Leeds (England), for his studies on the molecular structure of fibrous proteins. Astbury was named fourth recipient of the foundation's T. Ducket Jones memorial award.

Book Reviews

Predestined Educational Inequalities Today

Slums and Suburbs. A commentary on schools in metropolitan areas. James Bryant Conant. McGraw-Hill, New York, 1961. viii + 147 pp. Cloth, \$3.95; paper, \$1.95.

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James Conant writes about the complex way in which ecological and social class factors interact and mutually reinforce each other to produce gross inequalities of educational opportunity in the United States. This, of course, is a phenomenon common to all the industrial countries of the world, in which local communities vary widely in social composition. Everywhere it is the case that the larger the proportion of manual agricultural laborers in the local population is, the poorer is the local cultural and educational endowment and the lower is the modal level of social and educational aspiration. Everywhere these differences result in disparities, according to locality, in educational achievement between children of similar measured intelligence or aptitude, within as well as between the social classes. From top to bottom in the social and intellectual hierarchy, the children attending schools in the prosperous suburbs emerge relatively better equipped academically than the children from schools in small villages or large industrial cities.

Conant, however, is concerned with demonstrating the exacerbating influence, in the case of the United States, of two particular factors: the system of financing public education and the ecological segregation (de facto, not de jure) of ethnic minorities-in particular, the concentration of migrant Negroes in the slums of the big northern cities. He bitterly regrets the historic failure of Congress to establish a federal policy for education. He paints a deeply disturbing picture of a frustrated and delinquent generation of largely unemployed Negro adolescents, a picture of financial handicap, impoverished material equipment, high pupil-teacher ratios, and high teacher turnover in precisely the areas of greatest educational need—namely, the slums in which congregate the large transient families of unemployed, unskilled, unschooled, and often criminal or mentally sick breadwinners on the move from the South.

From his depressing catalog of social and individual miseries in these areas, Conant derives a number of interesting and controversial propositions. The problems of Negro education are no different from those of all underprivileged social groups; thus, we should not allow racial considerations to cloud the formulation of policy. Enforced mixing of de facto segregated school populations is less important than adult education among parents and literacy drives among slow learners in the schools. The problems of Negro unemployment, however, are characteristic and justify special measures: the prohibition of discrimination by employers and labor unions; the financing of public works to provide employment, especially for young people aged 16 to 23, of whom more than 50 percent are unemployed; and the vocationalizing of the high school after the 10th grade.

The purely pedagogical problems of slum schools that deal with large bodies of culturally deprived slow learners during 12 years of compulsory education lead Conant to formulate an educational heresy: that the curriculum and organization of schools should reflect the socioeconomic status and needs of the communities they serve and, in particular, that they should prepare pupils directly and explicitly for the local labor market.

When Conant derives the same proposition from his study of the wealthy college-oriented suburbs at the other end of the spectrum of inequality, its heretical character will no doubt strike his predominantly middle-class readers

with more force. Here in the suburbs is a dual problem: on the one hand, how to raise standards of preparation for entry to higher education and, in particular, how to broaden the range and stiffen the content of advanced courses in the high school; on the other hand, how to diminish the indiscriminate emphasis on college-going among suburban parents by arousing a sense of the value of vocational courses in the high school and thus lessening their frenzied desire for the longest possible education for their children regardless of its content and quality.

A substantial investigation related to the first problem yielded "academic inventories" for six large, selective, academically oriented high schools. These data are presented to substantiate Conant's contention that it is both desirable and possible for the American equivalents of European sixth-formers to have and to profit from a comparable academic load. The second problem is perhaps more intractable in a society in which upward social mobility through education is not the privilege of a selected and sponsored minority but is open to all who will make the attempt, regardless of whether they can succeed. Conant confines himself to the suggestion in this connection that counseling in suburban high schools should be "realistic" in relation to college-going and that the schools should look betimes to the possibility of vocationalizing the advanced courses undertaken by children of average and below-average ability. That is, he reiterates the educational heresy in a context in which it is likely to prove even less acceptable to liberal educators.

JEAN FLOUD

Institute of Education, University of London

Astronomy-Geophysics

The Rotation of the Earth. A geophysical discussion. W. H. Munk and G. J. F. MacDonald. Cambridge University Press, New York, 1960. xix + 323 pp. Illus. \$13.50.

Study of the variations of the earth's speed of rotation proceeds along two lines: determining the variations from astronomical observation and attempting to provide geophysical explanations for them. As the subtitle indicates, this book is chiefly concerned with the second problem, a large one. "The diversity of

the subject is appalling. It touches on every branch of geophysics." Hence the authors discuss not only the astronomical data but also wind and air masses; atmospheric, oceanic, and bodily tides; sea level; rigidity of the earth's mantle; and motion in the Earth's fluid core. For good measure, one piece of Jules Verne's science fiction is discussed.

The dynamics of the variations in speed of rotation and the motions of the axis of rotation, such as the 14-month Chandlerian motion, are treated together. Observational data are analyzed in terms of the "power spectrum." Variations in speed—for example, monthly, annual, irregular, and secular variations — are considered as strong lines in the spectrum.

Secular retardation is given extensive treatment. The authors find that, as yet, there is no satisfactory explanation of how the energy lost by tidal friction is dissipated.

Polar wandering during vast ages of the past is treated in the chapter on geological variations. (Precise astronomical observation goes back only 60 years.) Paleomagnetic evidence, much of it speculative, is discussed, and the authors conclude, "The story of polar wandering is varied and complex. Our principal conclusion is that the problem is unsolved."

The book evidently stems from researches published since 1950 by M + V, where M denotes W. Munk and V is a variable author—G. Groves, E. M. Hassan, R. Haubrich, G. J. F. MacDonald, R. Miller, Y. Mintz, or R. Revelle. The subjects, however, are treated anew, critically and systematically, and the authors do not attempt to force theories to fit the facts.

The volume has been well prepared; it contains four pages of symbols, a reference bibliography, and an index. The faults are few. The photograph in the frontispiece is not described; the linear scale shown has no dimensions. (I have the same feeling toward unexplained photographs in a technical book as I have toward the absence of an index.) According to the authors, "The geophysical discussion is intended for a reader without special training in various branches of this science." Can they really mean this? The description of power spectra (in appendix 2) is far too condensed to be useful. Two methods for representing changes in speed of rotation are ascribed to D. Brouwer (1952), but Brouwer says he presented only one.

This book was awarded the Mono-

graph prize of the American Academy of Arts and Sciences for the year 1959 in the field of physical and biological sciences. As far as I know, it is the only comprehensive treatment of the rotation of the earth, and I recommend it for use in any library concerned with astronomy, geodesy, and geophysics.

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"Mechanistic" Reinterpreted

The Mechanization of the World Picture. E. J. Dijksterhuis. Translated by C. Dikshoorn. Oxford University Press, New York, 1961 viii + 539 pp. Illus. \$18.60.

All students of the history of science concerned with the so-called Scientific Revolution of the 17th century will welcome this English translation of Dijksterhuis' De Mechanisering van het Wereldbeeld (Amsterdam, 1950). This work, both in its original form and in the German translation (1955), has already become a classic, for its author is one of the most profound interpreters of the history of mathematics and mechanics. The author modestly claims that his interpretation of the mechanization of physical science is not "intended as a handbook for historians of science: [that] it has been written for the general reader with a broad interest in the subject." But let me assure the readers of this review that many historians of science have already learned much from it and many more will learn from it.

To the subjects that he touches in this substantial volume, Dijksterhuis brings accurate, careful, and up-to-date (at least to 1950) scholarship. For example, many of the results of Anneliese Maier's superb investigations into medieval natural philosophy are incorporated. The only points of vexation with this translation are that it costs the American reader \$18.60 and that the translation took so long to appear.

Starting with the Pythagoreans, the author steps his way surely through the major phases of Greek natural philosophy, the scientific legacy of antiquity, and the science of the Middle Ages and the Renaissance; he concludes with an examination of the evolution of classical science through Newton. I think no other single volume makes so clear the relationships of ancient and medieval science and philosophy to the

development of early modern physical science—in connection with the growth of the substantive ideas of classical (Newtonian) physics and with the underlying philosophical concerns.

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In the epilogue Dijksterhuis discusses the nature and meaning of the "mechanistic" viewpoint of classical science which developed in the 17th century. He examines and rejects a number of possible ways of interpreting the "mechanistic" character of Newtonian science: (i) It is "mechanistic" because it conceives of the universe as a "machine," created by God; or (ii) it is "mechanistic" because the hidden mechanisms of nature are considered to be essentially the same kind of mechanisms as simple instruments or machines; or (iii) its theories are "mechanistic" because they describe processes as possessing the same inanimation as machines. Rejecting all of these as the most fundamental way of interpreting the mechanism of this early modern physical science, Dijksterhuis suggests another possible interpretation-that it is "mechanistic" in the sense that it is fashioned "with the aid of mechanics." While this definition of mechanistic may seem to be circular and to lead back to the original picture of the machine, he points out (page 498) that in fact this is not so "if one bears in mind that the science called mechanics had emancipated itself in the 17th century from its origins in the study of machines, and had developed into an independent branch of mathematical physics dealing with the motion of material objects and finding in the theory of machines only one of its numerous practical applications." In line with this suggested interpretation of classical physics as "mechanistic," Dijksterhuis is thus able to highlight the difference between medieval and early modern mechanics, namely, that, while the former on occasion uses mathematics and mathematical methods, the latter is essentially mathematical, that is, its basic concepts are mathematical. Many other wise things about the relation of Newtonian to modern science are briefly discussed, as the author brings his fine treatment to a close.

An excellent bibliography completes the book; unlike the main body of the text, it includes titles published as late as 1959. Thanks are due to the Oxford University Press for the handsome makeup of the volume.

MARSHALL CLAGETT Institute for Research in the Humanities, University of Wisconsin

Russian Prehistory

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L. 134

Archaeology in the USSR. A. L. Mongait. Translated and adapted by M. W. Thompson. Penguin Books, Baltimore, Md., 1961. 320 pp. Illus. \$1.45.

The Russian original of this work is authoritative both as a document of what Soviet archeology is like and as a description of its findings down to the early 1950's. It has been reviewed elsewhere [American Anthropologist 59, No. 1, 183 (1957)], and critical comments by the translator are included in the Pelican edition. Mongait's volume is an excellent synthesis. Its principal faults are nationalistic bias and bombast and an almost total lack of concern with concepts and methods (as opposed to techniques). This latter failure is frequent in Soviet archeological writings and probably stems from a desire to avoid "formalism"—that is, preoccupation with problems seemingly far removed from the ultimate objective, in this case "the proper understanding of historical development."

Thompson's translation, while not always elegant or even idiomatic, has the great merit of always being clear in meaning. The translator's foreword (pages 15-31) explains the conception of the book, provides environmental and ethnographic information on the Soviet Union, and outlines the growth of archeology in Russia since prerevolutionary times. Parenthetical remarks by the translator within the text are also, for the most part, helpful, though a few seem trivial and unnecessary. In dealing with the eternal and vexing problem of finding the correct nominatives of Russian proper names (often present in the original only in declined or adjectival forms), Thompson did not always look hard enough. In addition, some misrenderings-such as Kazakhistan, Khvoika, Varakhsh, and Saltov (for Kazakhstan, Khvoiko, Varakhsha, and Saltovo)-can be explained only by carelessness, since the correct unmodified forms occur in the Russian original.

As stated in Thompson's foreword, this is not a complete translation. Omissions include politically motivated passages, enough of which have been retained, however, to preserve the flavor of the original. In addition, Thompson also chose to drop a fair number of specific mentions of sites, individuals, and publications, "to reduce the burden of foreign names." This decision does

not consider the fact that the reader always has the choice of ignoring information when it is provided, but not of supplying it when it is omitted. In the present case, this sort of trimming seems a poor move, because the original is already a rather simplified presentation of a vast subject.

PAUL TOLSTOY

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Policy Questions

Structure of Higher Education. William O. Penrose. Van Keulen, The Hague, Netherlands, 1961. 208 pp.

Because they fulfill new functions and have accepted fresh responsibilities, universities are everywhere changing very quickly. They are also growing at a fantastic rate: it seems possible that, at least in the more advanced countries, tertiary education may be universalized and nationalized during the next 50 years, just as secondary education has been during the last 50. As a consequence of rapid evolution, perplexing problems of policy arise, some of which can be usefully elucidated by comparative analysis. While it is unlikely that the educational practices or institutions of any country can be simply transplanted into another, confrontation of two or more systems may help us to identify, isolate, and understand the forces which shape policy as well as the historical and social factors which have to be taken into account by policy makers.

In his new book, William Penrose, dean of the School of Education at the University of Delaware, describes and analyzes the organization and administration of higher education in the United States and the Netherlands. He begins by dealing, in a general way, with the United States: listing the aims and purposes of education; describing the administrative and organizational structure of typical universities as well as the powers and duties of officers such as the president; considering the legal status of institutions of higher education; and so forth. Then comes a very interesting and informative chapter on "Super-institutional" controls: the influence of the state and of other official and nonofficial bodies upon public and nonpublic institutions. Penrose then discusses governing boards; their nature, powers, and functions; selection and appointment of staff; committee organizations; the role of professional administrators; academic structure; and other related topics. From all this emerges a clear and detailed picture of the ways in which American universities and colleges are run and organized. One begins to see who, in fact, makes the important decisions and how these key individuals are themselves controlled. One understands to what kinds of pressures the institutions respond and why institutions seem to be so cautious and conservative in some respects, so bold and progressive in others.

The 40 pages which Penrose devotes to the Netherlands seems to me much less interesting and valuable. He, himself, gives the explanation. He worked with an official of the Dutch government and relied entirely upon interviews with administrative and academic leaders. It is noteworthy that, while many American books and papers are listed, there is not a single reference to any material available in the Dutch language. As a result, we have, in the author's own words, "a description, analysis and tentative evaluation of higher education in the Netherlands which may seem less scholarly, in the usual sense, than the section on the United States." With these reservations, it can be readily admitted that the careful "studies of selected institutions," which cover the administrative and organizational structure of Leyden (State), Delft (Technological), Amsterdam (Municipal), Amsterdam (Reformed Church), and Rotterdam (Economics), are an exceedingly useful and exact summary of the existing situation,

All this is valuable. In addition, Penrose's statements of general principles of administration as well as his suggestions of topics where research is needed are helpful. Nevertheless, three criticisms of fundamental importance must be urged. First, the analysis seems somewhat superficial. Administrative and organizational forms have not usually been designed simply to serve present-day purposes and aims, especially not those explicitly stated in documents. They are usually adopted simply because no one could think of anything new, or else they are invented because they seem to be the only ones that can possibly deal with the conflicts of interest, with the social and individual problems existing at the time of their adoption. We inherit them from the past, and they are not always well adapted to the problems which arise at the present. In other words, I am convinced that the analysis of university administration and organization must rest upon solid and detailed historical studies. If we are to understand why things are as they are, historical analysis is essential, and for this a brief historical account is a quite insufficient substitute. We must show how and why the past is important and why it is still with us. Second, the analysis of a social institution, such as a university, must refer very closely to the sociological structure of a country (the class structure) as well as to its economic needs in relation to its financial capacity to bear the cost of extended tertiary education. Here sociological and historical analyses complement each other. Third, administrative practices and structure should not be evaluated or measured against general criteria such as those listed by Penrose, but rather by considering the ways in which they make it possible to handle specific problems. A few examples of the latter may be mentioned: Are students being admitted to tertiary education in numbers sufficient to satisfy needs? Is talent being wasted? Are children of poor parents being kept out? Are students being allocated in the best way among institutions and faculties? Are the staff given sufficient freedom to apportion their time wisely among research, committee work, and teaching? Are promising students given sufficient stimulus? Are funds sufficient to match needs? The question that has to be asked in each case is: In what ways do administrative and organizational forms help or hinder the solution of problems of this kind? Such criteria are more significant than those which concern chiefly general issues like the training of elites or whether there exists a unified and comprehensive authority within an institution. These, too, have their importance, of course, but at another and less practical level.

These criticisms should not dissuade any one from studying Penrose's book, so full of wisdom and so evidently the fruit of ripe experience. We have reason to be grateful for what is, in a sense, a pioneer effort which should act as a stimulus to others. We need many enquiries of this kind, dealing with the tertiary systems both of industrialized and of underdeveloped countries. All those who are concerned with the formation and formulation of university policy owe a debt of gratitude to Penrose for the careful and painstaking work he has done.

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Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

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California Academy of Sciences. Occasional Papers, No. 30, "The immature stages of Callomyia, with the description of a new species of this genus (Diptera: Platypezidae)," Edward L. Kessel, 10 pp. Proceedings, vol. 30, No. 3, "Large Terebras (Mollusca) from the eastern Pacific," G. Dallas Hanna and Leo George Hertlein, 13 pp.; No. 4, "Four species of Chitons from the Panamic Province (Mollusca: Polyplacophora)," Allyn G. Smith. 9 pp. The Academy, San Francisco, Calif., 1961.

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Hunger. Can it be averted? E. John Russel and Norman E. Wright, Eds. British Assoc. for the Advancement of Science, London, 1961. 80 pp. 5s.

An Inexpensive Science Library. A selected list of paperbound science books. Compiled by Hilary J. Deason and Robert W. Lynn. AAAS, Washington, D.C., ed.

5, 1961. 87 pp. \$0.25. Annotated, selected listing of 679 titles recommended for high school students, college undergraduates, teachers, and laymen.

Jacobsen-McGill Arctic Research Expedition to Axel Heiberg Island, Queen Elizabeth Islands. Preliminary Report of 1959–1960. Fritz Müller et al. Barbara S. Müller, Ed. Dept. of Geography, McGill Univ., Montreal, Canada, 1961. 219 pp. \$2.50. Papers on glaciology, geophysics, meteorology, geology, geomorphology, botany, permafrost, mountaineering, and mapping.

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Reports

Presence of Toxic Factors in Urine from Schizophrenic Subjects

Abstract. Mice injected intraventricularly with toxic substances extracted from urine exhibited differential behavioral changes of novel character. Extracts from schizophrenics showed significantly more toxicity than those from nonschizophrenics. Further purification by a chromatographic procedure indicated that at least two currently unidentified active components are present.

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This study is part of a larger coordinated program in which the clinical, psychological, biochemical, and biological aspects of schizophrenia are being investigated. Among tests used in this program to detect and evaluate characteristics of this illness, many bioassays have been explored. The one reported here seems especially promising as an objective criterion of schizophrenia. The study under discussion is an extension of the work of Wada and Gibson (see 1); the chemical extraction methods differed from theirs, and the mouse was substituted as the experimental

Urine was collected from 44 male patients, 18 to 50 years old, who had been kept for at least 4 weeks under controlled conditions, which included a uniform diet, uniform ward routines, and absence of drugs. The hospital population included 23 schizophrenic patients, roughly equal numbers of chronic undifferentiated and paranoid patients, and 21 nonschizophrenic patients, mainly sociopaths, some with alcoholism. The volume of urine for 24 hours was 20 to 25 percent lower in the schizophrenic than in the nonschizophrenic patients.

Twenty-five percent of the fresh 24hour collection from each subject was stirred with 20 g of activated charcoal (Norit) (2) for 1 hour and then filtered. (The wet charcoal was washed with 50 ml of water and filtered; this step was found unnecessary and was discontinued.) The active components were extracted from the charcoal with a mixture of 50 ml of water (pH 11.9 to 12.0) and 70 ml of acetone. The mixture was stirred for 1 hour, and again the extract was collected by filtration. The charcoal was transferred to a beaker, 10 ml of water (pH 11.9 to 12.0) plus 50 ml of acetone was added, the mixture was stirred for 30 minutes, and the washing was collected by the same method. The two extracts were combined and lyophilized to dryness. The dried gummy residue was dissolved in 10 ml of water to give the "stock" solution. This was diluted fourfold with Tyrode solution, and 0.02 ml was injected into the brains of mice (strain C. F. No. 1, male, 40 to 50 days old) (3) by the standard technique used by bacteriologists (4). An India ink injection was found, in most cases, in the lateral ventricles. After injection the animals were observed over a period of several hours for changes in gross behavior. Control injections of Ringer's solution or Tyrode solution produced no changes.

Each diluted stock solution was administered to ten mice; behavioral changes, if they occurred, regularly appeared in seven or more of these. Nineteen of 23 samples from schizophrenic subjects produced abnormal behavior; 16 of 21 samples from nonschizophrenic subjects produced only slight effects (Table 1). The abnormal responses were as follows: In most cases, immediately after the injection the mice assumed a hunched-up position, with the hind legs spread far apart; the tails were elevated perpendicular to the body (Straub's tail phenomenon), and the mice were over-

sensitive to both sound and touch. This state lasted for 1 to 5 minutes and was followed by a second phase, which lasted a few minutes to several hours. Seven patterns (Table 1) were distinguished, from maximal excitation to maximal depression. Pattern 1 showed running movements followed by clonic and tonic convulsions; death occurred in 5 to 30 minutes. The survivors (pattern 2) remained immobile for several hours and appeared normal 24 hours later. Pattern 3 showed a novel behavioral phenomenon (5)-abnormal jumping, with crying, at the rate of 40 to 100 jumps per minute, lasting for 10 to 20 minutes and followed by immobility for another 100 to 160 minutes and then a return to normal. Pattern 4 was a stupor lasting for 40 to 120 minutes, during which time the mice were immobile and unresponsive to sound or touch. Animals could be left in an abnormal position during this period, but prodding evoked movement. Pattern 5 differed from pattern 4 in that the mice could not be placed in an abnormal position. Pattern 6 was a decrease in activity and playfulness, lasting for 20 to 30 minutes. Pattern 7, a quieting for 20 to 40 seconds after injection and full return to normal, was the "control" response to Ringer's or Tyrode solution and to some extracts from nonschizophrenic subjects. For six samples, selected at random for each group, the LD₈₀ values (6) for urinary extracts from schizophrenic and nonschizophrenic subjects were found to be 35- and 80-percent dilutions, respectively, of the pooled stock solutions. The ED50 values for convulsions and/or abnormal jumping with crying-behavior response were

Table 1. Effects of "intracerebral" injection in mice of urinary extracts from schizophrenic and nonschizophrenic subjects

| Behavioral changes | phrenic (23 | Nonschizo- phrenic (21 samples) |
|-------------------------------|---------------------|---------------------------------------|
| Patte Convulsion to death | ern No. 1 | 0 |
| Patt Convulsion to coma | ern No. 2 | 2 |
| Patte Jump with cry to stu | ern No. 3 por* 4 | 3 |
| Stupor* | ern No. 4 | 0 |
| Patt Unresponsiveness | ern No. 5 | 2 |
| Depression Patt | ern No. 6 | 10 |
| No change | tern No. 7 | 4 |

See text.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should not repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to one 2-column fig-ure (that is, a figure whose width equals two col-umns of text) or to one 2-column table or to two 1-column illustrations, which may consist of two figures or two tables or one of each. For further details see "Suggestions to contributors" [Science 125, 16 (1957)].

9.4- and 36-percent dilutions for the extracts from schizophrenic and nonschizophrenic patients, respectively.

These values strongly indicate that the observed differences are due to quantitative rather than qualitative fac-

One-dimensional descending chromatograms of the concentrated stock solution [Whatman No. 1 paper; 24° to 27°C; solvent: isopropyl alcohol, ammonium hydroxide, and water (40:1:9, vol/vol)] revealed several isolated spots under ultraviolet light of short wavelength. The volume of the water extracts for each of these spots was reduced to a proper amount and the extracts were injected into mice. The substance (or substances) from a blue spot (approximate Rr value, 0.69) produced pattern 4: the substance (or substances) from a purple spot (RF value, 0.56) produced patterns 1, 2, and mainly 3, but with more frequent jumps (80 to 100 per minute) and a longer period of jumping behavior (20 to 30 minutes). From another area of the chromatograms, substances were obtained that produced violent scratching for 15 to 30 minutes, or Straub's tail phenomenon, lasting 20 to 40 minutes in the mild case. Water extracts from other areas produced only slight effects. The chromatographic separations were confirmed by several replicate runs.

Work is continuing on the identification of the active substances, which seem to be relatively stable and simple molecules, and on their significance in schizophrenia (7).

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J. T. Litchfield, Jr., and F. Wilcoxon, Pharmacol. Exptl. Therap. 96, 99 (1949). This study was supported in part by This study was supported in part by U.S. Public Health Service grants MY 1971, MY 1972 (Schizophrenia and Psychopharmacology Joint Research Project, University of Michigan and Ypsilanti State Hospital, R. W. Gerard, principal investigator), MY 4366 (A), and MY 4598. We acknowledge the guidance and helpful suggestions of Dr. Gerard and the assistance of Drs. Dukay, Yuwiler, and Fox, and of Mrs. Reuell and ward personnel. Permanent address: Department of Neuropsychiatry. Sapporo Medical College. Sapporo-This study

chiatry, Sapporo Medical College, Sapporo, Japan.

7 June 1961

Epileptogenic Cerebral Electrical Activity and Serotonin Levels

Abstract. Chronically epileptic cats and monkeys showed marked activation of paroxysmal electrographic abnormalities both in the original focus and in a number of structures with secondarily altered functional states after intraperitoneal injection of the serotonin precursor 5-hydroxytryptophan (10 to 25 mg/kg) plus vitamin Bo. Much less 5-hydroxytryptophan was required to produce such epileptogenic activation if the animals had previously been treated with Marsilid, a monoamine oxidase inhibitor. Marked paroxysmal activity in epileptic animals was also produced by injection of Marsilid alone or of Marsilid in combination with reserpine. Since all of the activating agents used have been shown by others to elevate brain serotonin levels, the epileptogenic activation may be correlated with such high levels. Since the effects were at least partially blocked by atropine, such "serotonin-induced" activation may possibly involve some cholinergie mechanism.

During recent years, increasing significance has been attached to the alteration of the brain levels of neurohumoral agents such as serotonin and the catecholamines in the modification and organization of behavior. However, very little attention has been paid to the possible effect of such neurohumoral agents on epileptogenic electrical activity. In a recent study it was concluded that elevation of the serotonin level was responsible for the decrease in electroencephalographic abnormalities in epileptic patients after administration of Marsilid (1).

It is the purpose of this study (2) to show that, on the contrary, measures which are known to elevate serotonin levels cause increased electroencephalographic abnormalities in epileptic ani-

Three monkeys (two normal, one epileptic) and six cats (two normal, four epileptic) were used. All the animals had 42 to 50 electrodes permanently implanted in both the cortical and the deep structures (3). The epileptic animals had been made epileptic by placing aluminum hydroxide in one sensorimotor or frontal polar cortex at least 3 to 4 years prior to the experiment under discussion (4). A number of agents, or combinations of agents, which have been shown by others to increase the brain levels of physiologically active serotonin were used. These were (i) the serotonin precursor DL-5-hydroxytryptophan (5-HTP) (10 to 50 mg/kg), plus the decarboxylase coenzyme vitamin B_0 (50 mg/kg) (5); (ii) the monoamine oxidase inhibitor Marsilid (100

mg/kg), alone (6) or with 5-HTP (7); and (iii) Marsilid plus reserpine (0.1 mg/kg) (7). All the agents were given intraperitoneally. The electroencephalographic recording was made at least once every hour up to 24 hours after administration of any single agent. The time sequence of the administration, when more than one agent was given, is specified in the legend to Fig. 1.

None of the measures used had a notable effect on either the behavior or the electroencephalogram of the normal animals, except that some drowsiness and electrographic slowing was noted in normal animals given the larger doses of 5-HTP (25 mg/kg) or the smaller doses of 5-HTP (15 mg/kg) 17 to 20 hours after administration of Marsilid.

In epileptic animals, on the other

hand, all of these agents produced marked activation of spontaneously occurring epileptic abnormality. Augmented paroxysmal discharges, of identical morphology and localization of spontaneous abnormality, occurred almost continuously up to 8 hours after administration of 5-HTP (15 to 25 mg/kg) plus vitamin Bo (50 mg/kg) (Fig. 1, d-f). However, such electrographic evidence of epileptogenic activity was not accompanied by any behavioral seizure phenomena. When the animal was injected with Marsilid 17 to 20 hours before the administration of 5-HTP, as little as 10 mg of the latter per kilogram produced a similar but greatly intensified effect (Fig. 1j). Electrographic abnormalities, somewhat less marked but of almost identical morphology and localization, were produced in epileptic animals by administration of Marsilid or reserpine alone (Fig. 1i, k, I), or, more strongly, by Marsilid plus reserpine (Fig. 1, m,n). While the early effects of reserpine alone (Fig. 1k) and of 3,4-dihydroxyphenylalaine (DOPA) plus 5-HTP (Fig. 1g) were very similar, later, at 24 hours (Fig. 11), the effect of 5-HTP was clearly predominant (Fig. 1, d-f and h). This finding is compatible with the view (8) that reserpine simultaneously releases physiologically active serotonin and catecholamines in the brain but that, because of the very rapid synthesis of serotonin (9), the effect of free serotonin is predominant in later reserpine action. No such epileptogenic-activating effect was noted when vitamin Bo was given, either alone or with DOPA (25 to 100 mg/kg), the precursor of the catecholamines. The latter had eliminated all the spontaneously occurring epileptogenic ab-

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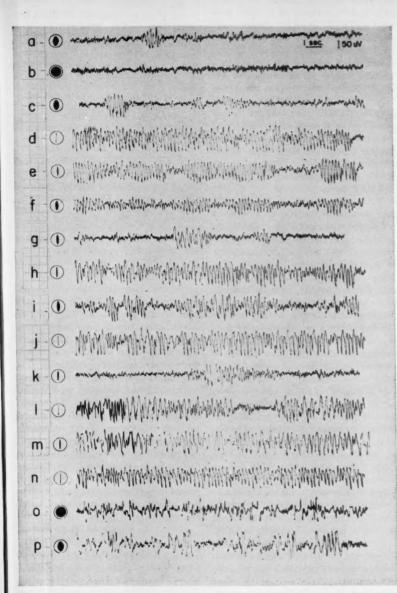


Fig. 1. Electhoencephalographic recordings from the left parietal cortex of epileptic cat No. 40. This cat was made epileptic about 4 years ago by placing aluminum hydroxide on the left sensorimotor cortex. The original focus was subsequently removed about 2 years ago. The size of the pupils at the time of recording is shown at left. a, Control resting state; relaxed. b, DOPA (25 mg/kg) plus vitamin B₆ (50 mg/kg), at 1 hour; very alert, attentive. c, Same as above, at 4 hours; relaxed. d, 5-HTP (25 mg/kg) plus vitamin B₀ (50 mg/kg), at 1 hour; very frightened, yowling, hissing when approached. e, Same as above, at 4 hours; no yowling or hissing, accepts caressing. f, Same as above, at 8 hours; under slight sedation. g, DOPA (25 mg/kg), 5-HTP (25 mg/kg), plus vitamin B₀ (100 mg/kg), at 1 hour; very alert but scared, hissing when approached. h, Same as above, at 4 hours; less alert, quiet and friendly. i, Marsilid (100 mg/kg), at 17 hours; very quiet. j, 5-HTP (10 mg/kg) plus vitamin B₀ [50 mg/kg, 17 hours after Marsilid (100 mg/kg)], at 1 hour; frightened, salivating, yowling, hissing when approached, diarrhea. k, Reserpine (0.1 mg/kg), at 4 hours; relaxed. l, Same as above, at 24 hours; markedly sedated, diarrhea. m, Reserpine [0.1 mg/kg, 17 hours after Marsilid (100 mg/kg)], at 4 hours; relaxed. n, Same as above, at 24 hours; markedly sedated, diarrhea. o, Atropine [1.0 mg/kg, 3 hours after reserpine (0.1 mg/kg), which was given 17 hours after Marsilid (100 mg/kg)], at 1 hour; relaxed and quiet. p, Same as above, at 21 hours (24 hours after reserpine, 41 hours after Marsilid); relaxed but not sedated.

normalities in the same animals (Fig. 1, b and c). When DOPA and 5-HTP were given simultaneously, together with an adequate amount of vitamin B. no immediate effect was observed until about 4 hours after administration, when an effect predominantly that of 5-HTP appeared (Fig. 1, g and h).

Three out of five epileptic animals given 15 to 50 mg of 5-HTP per kilogram developed an overt behavioral disturbance characterized by an attitude of extreme fright, with yowling, hissing, intermittent visual searching, and abrupt retreat. Such behavior was never observed in normal animals given up to 50 mg of 5-HTP per kilogram.

These results suggest that there may be a correlation between the epileptogenic activation noted and elevation of brain serotonin levels. Since barbiturates have been reported to increase brain serotonin levels (10), the well-known phenomenon of barbiturate activation of paroxysmal epileptogenic activity may involve the same biochemical process. The relative inertness of normal animals in response to the agents used suggests that epileptogenic cerebral structures may be hypersensitive to serotonin.

Behavioral and electrographic studies of modified levels of brain neurohumoral agents in cats and monkeys (11) have led to the belief that a change in the level of any single neurohumoral agent may be less important than production of a disequilibrium among the various endogenous agents. In this connection my co-workers and I have found that the paroxysmal abnormalities induced by administration of 5-HTP and Marsilid in conjunction with reserpine are at least partially eliminated by the administration of atropine (Fig. 1, o and p). This finding is difficult to explain, but the possibility that the cholinergic mechanism is involved in such activation is now being investigated. A recent report that high levels of serotonin markedly reduced cholinesterase activity (12) seems to support such a possibility. JUHN A. WADA Kinsmen Laboratory of Neurological Research, Department of Psychiatry,

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17 July 1961

Effect of Dietary Nitrate on **Thyroid Function**

Abstract. Experimental results indicate that 0.31 and 0.92 percent dietary nitrate, when consumed by rats and sheep respectively, can affect the normal iodine metabolism of the thyroid gland. The dietary level of iodine appears to be highly important when nitrate is present in the diet.

It has been shown by Wyngaarden et al. (1) that several monovalent anions, including nitrate, when injected into the animal, can interfere with normal iodine metabolism of the thyroid gland. The effects of nitrate in natural feeds has concerned animal scientists in recent years (2). This report attempts to assess the effect of dietary nitrate on the normal functioning of the thyroid gland.

The method of Premachandra and Turner (3) was used to determine the goitrogenic effect of nitrate both qualitatively and quantitatively. Adult fe-

Table 1. Effect of dietary nitrate on serum total I^{IB} , serum-protein-bound I^{IB} , and blood NO3 of sheep.

| Activity (count/min per 100 ml serum) | | Av. blood NO ₃ | |
|--|-----------------------------|---------------------------|--|
| Av. total serum I ¹⁸¹ | Av. PBI ¹⁸¹ | (mg/100 ml) | |
| | Control (five | sheep) | |
| 93,170 | 83,510* | 0.80 | |
| Treated | with 1.5 percent 53,950* | KNO3 (six sheep) 1.93 | |

* Significantly different (p < .01).

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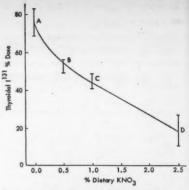
male rats weighing 200 to 300 g were kept under conditions of uniform temperature of 75°F. The animals were fed a finely ground corn-soybean oil meal diet calculated to contain 135 ppm iodine, for 1 week. Each rat was then injected with 3 µc of carrier-free I181. A 24-hour external thyroid count was made on ether-anesthetized animals placed on a lead plate with the thyroid gland over a scintillation probe. Measurements were made with a scintillation counter connected to a rate meter. Nitrate was added to the ration as KNO₃ at concentrations of 0.5, 1.0, and 2.5 percent.

The results, shown in Fig. 1, indicate that dietary KNO3 at a level of 0.5 percent adversely affected the iodine uptake of the thyroid gland of the rat. This level of nitrate is not uncommon in some hays and ensilages (4). The higher levels of nitrate are more commonly found in hay, pasture, and ensilage that are grown either under conditions of unbalanced fertility or the onset of drought or other adverse conditions for plant growth.

Since the above-mentioned feeds are normally given to ruminants, sheep were fed a ration containing 1.5 percent KNO3. This ration was composed of 58 percent corn cobs, 24 percent corn, 8 percent soybean oil meal, 7 percent molasses, 2 percent minerals, and 1 percent urea. The concentration of serum I131 fixed as protein-bound iodine 6 days after 100 µc I131 had been injected was used as the criterion (5) for normal thyroid function. Methemoglobin was determined and no difference was found between the control and experimental groups. The results in Table 1 indicate that some nitrate passed through the rumen unchanged and that this nitrate interfered with normal thyroid function.

Muhrer et al. (2) found symptoms of vitamin A deficiency in cattle that consumed nitrate. Garner et al. (6) showed increased depletion of vitamin A in rats fed nitrate. The function of the thyroid in the conversion of carotene to vitamin A is still debated. However, Johnson and Bauman (7) showed that a functioning thyroid gland is necessary for this conversion. In view of these facts, it is conceivable that the vitamin A deficiency is an indirect result of abnormal thyroid function induced by the nitrate.

From a practical view, it is fortunate that the interference of certain monovalent anions with normal iodine metabolism of the thyroid gland can be re-



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Fig. 1. The effect of dietary KNO_a on thyroidal uptake of I¹⁸¹. Vertical bars represent standard error of the mean. There were eight, six, six, and four rats in treatments A, B, C, and D, respectively. All treatments were significantly different from control A: B, p < .05; C, p < .01; D, p < .01.

versed by increasing the iodine concentration of the diet (1). This may help explain the extreme variability in nitrate effect reported by investigators located in different geographic areas. The dietary level of iodine is apparently important for evaluating a feed suspected of containing nitrate.

This research indicates that dietary nitrate can adversely affect the normal functioning of the thyroid gland and suggests that some of the symptoms encountered in the field may be a result of impaired thyroid function of animals. On the basis of this work, we strongly recommend that animal rations suspected of containing nitrates be supplemented with adequate amounts of iodine and vitamin A (8).

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- 2 June 1961

Thalamic Reticular System and Cortical Arousal

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Abstract. By electrocoagulation of the thalamic posterior commissure, the electroencephalographic arousal by high frequency stimulation of the thalamic unspecific nuclei was prevented, whereas the synchronizing influence on the cerebral cortex remained intact. On this ground, the role of the "thalamic reticular system" in the control of the cerebral rhythms is discussed.

Behavioral arousal and its ordinary electrocortical correlate (the electroencephalographic desynchronization) are known to depend upon the tonic influence of subcortical structures which form the "reticular ascending activating system" (1). This system is essentially composed of cell populations in the central core of the bulb, pons, and mesencephalon. Rostrally, the midline, intralaminar, and reticular nuclei of the thalamus are generally considered as the main last subcortical station. Indeed, a high-frequency electrical stimulation (more than 30 per second) carried therein would desynchronize the electroencephalogram quite as readily as if the arousing shocks were applied directly to the brain stem reticular formation lying caudally. As, in addition, a low-frequency stimulation (6 to 12 per second) of the same part of the thalamus elicits generalized recruiting waves similar to the spontaneous spindles seen at rest, it has been admitted that the cerebral rhythms are controlled from that region by common thalamocortical projections spreading toward both hemispheres. These are the main physiological arguments supporting the concept of a "thalamic reticular system" where critical frequencies of electrical stimulation are responsible for completely opposite effects: synchronization and desynchronization of the electroencephalogram.

In recent experiments performed on 35 cats unanesthetized at the time of recording, immobilized with Flaxedil, we have bilaterally destroyed by electrocoagulation a region corresponding approximately to the posterior commissure and pretectum. This lesion was posterior to the thalamus and limited to the dorsal aspect of the brain stem. Thereafter, we consistently failed to obtain a lasting electroencephalographic arousal by a previously effective 60- to 300-per-second stimulation of the thalamic nuclei: centralis lateralis, centralis medialis, paracentralis, reuniens, or rhomboidens (Fig. 1A). Sometimes there was a transient desynchronization, never outlasting the period of stimulation. Often spindles were seen during the excitation but most frequently they occurred at its outset (spindle tripping).

That the desynchronizing action of the thalamic stimulation was lost or strikingly reduced was further demonstrated by the following observation. Normally, the cortical synchronous potentials are swept off during the time of the electroencephalographic arousal. For instance, the recruiting responses to 10-per-second pulses applied in one of the intralaminar thalamic nuclei are depressed by a high frequency stimulation of the homologous contralateral nucleus (1). In our experiments this inhibiting effect disappeared after coagulation at the level of the posterior commissure (Fig. 1B).

It must be noted that the present results could hardly be explained on the ground of encroaching lesions of the thalamic system itself. Nor could it be argued that the cortical tonus had been lowered. Actually, the cortex was still able to desynchronize either spontaneously or by ordinary arousing procedures: upon injection of d-amphetamine, by electrical excitation of a peripheral nerve, or by stimulation of the mesencephalic reticular formation. So we must face the hypothesis that the desynchronizing action of the "reticular thalamic system" has to be necessarily mediated through the caudally situated reticular formation in order to reach the cortex. This is in agreement with Bremer's suggestion (2) that the cephalic portion of the reticular system depends on the lower portion for its functioning. Some recent data suggest that the thalamoreticular pathway passing at the site of the lesion could be a direct one (3).

Inasmuch as a backward action from diencephalic structures toward the lower brain stem is needed in order to elicit a generalized and lasting electroencephalographic arousal, there remains no definite evidence that these structures are more intimately implicated in the arousing mechanisms than other regions: for instance, the cerebral cortex, the cerebellum, or the various sensory afferences and central relays. Thus the physiological concept of a thalamic reticular system has to be questioned, at least in its ordinary formulation.

By special procedures, it is possible to isolate the synchronizing action of the thalamic unspecific nuclei. An anatomical transection at the level of the posterior commissure was shown to be often quite sufficient. However, a cortical desynchronization sometimes remained for the time of the stimulation. Fibers originating at a lower level in the brain stem are known to pass across the medial thalamus (4), and they are probably responsible for this transient cortical arousal when they are stimulated in their diencephalic course.

So, we attempted to use Nembutal, either by intravenous injection (15 mg/kg) or by topical application on the cerebral cortex (1.5 percent solution), in order to cancel the action of the excited *fibres de passage*. Under these conditions, we made the unusual observation that a 300-per-second stimulation of the thalamic midline or intralaminar

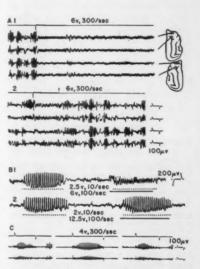


Fig. 1. Three electrocorticographic effects of a coagulation in the region of the pos-terior commissure. Experiments on three unanesthetized cats, immobilized with (A) The enduring and gen-Flaxedil. eralized desynchronization induced by a 300-per-second stimulation of nucleus centralis medialis, as shown in the control (A1), no longer appeared after a coagulation of the posterior commissure (A2). Calibrations: 100 µv, 1 sec. (B) Recording from the left anterior sigmoid gyrus. The recruiting responses to a 10per-second stimulation of the left nucleus paracentralis were prevented by a simultaneous 100-per-second stimulation of the right nucleus paracentralis (B1). After a coagulation of the posterior commissure, the inhibition of the recruitment was absent, even when twice as much voltage for the high-frequency shocks was used (B2). Calibrations: 200 µv, 0.5 sec. (C) Recordings from the anterior (upper trace) and posterior (lower trace) sigmoid gyri after coagulation of the posterior commissure and intravenous injection of 20 mg/kg of Nembutal. Under these conditions, a 300-per-second stimulation of the nucleus rhomboidens, which previously had an arousing effect, consistently induced spindling activities. Calibrations: 100 μv, 1 sec.

nuclei consistently elicited spindling waves on the cerebral cortex (Fig. 1C). The barbiturate by itself, that is, without any interruption of the postulated thalamoreticular connections, never induced this effect.

In our opinion, these latest results indicate that the unspecific thalamic system is mainly or solely concerned with the production of slow cortical activity. They also suggest that the thalamocortical mechanism of synchronization is not frequency-dependent with regard to the modalities of its activation. And finally, they give direct and further evidence that the recruiting and arousing systems of the brain are separated functional units, a fact which has already been postulated on other grounds (5; 6).

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7 August 1961

Psychomotor Coordination of Auditory and Visual Space at Birth

Abstract. Before it was 10 minutes old. a human neonate was able to turn its eyes in the direction of an auditory stimulus. This demonstrates that learning is not essential for a crude form of auditory localization, directional oculomotor response, and coordination of auditory and visual functioning.

It has long been believed that space perception is dependent upon extensive learning experiences (1) although the results of some studies (2) do not appear consistent with such a belief. If it could be demonstrated that responses

based upon space perception are present at birth, the nativist view of space perception would be greatly strengthened and serious doubt would be cast upon the empiricist view.

In 1952 I noticed that my child (born without anesthesia, by natural childbirth), about one-half hour after birth, turned her eyes in the direction of a soft click made near one ear or the other. This report describes a systematic attempt to replicate this observation.

The subject was born without pharmacologic anesthesia, by natural childbirth. Three minutes after birth, a series of trials were begun. On each trial a click was made (in predetermined order) with a toy "cricket" next to the right or left ear of the subject, who was lying on her back. Two observers independently recorded whether the eyes (whose movements were fully coordinated) moved to the infant's left, to the infant's right, or not at all, in response to each click.

As soon as the first click was made, the neonate, who had been crying with eyes closed, stopped crying, opened her eyes, and turned them in the direction of the click; it was clear to both observers that the movements occurred in response to the click. At about eight trials per minute, 52 successive trials were undertaken; the series was discontinued because the subject "lost interest," adapted, or satiated, in the sense that no further eye movements occurred in response to the clicks. When the experiment was over, the subject was only 10 minutes old.

The observers agreed substantially. On only one trial did they disagree on the direction of eye movement; on six trials, one observer recorded an eye movement while the other recorded none. There was perfect agreement on the remaining 45 trials; in 23 of these there was no eye movement. For 22 critical trials in which the observers both reported eye movement in the same direction, 18 were in the direction of the click and four in a direction opposite to the click. The difference between this distribution and chance (11 and 11) is significant at better than the .01 level by binomial expansion or by t-test based on the standard error of a proportion.

Although psychological experiments are usually performed on a fairly large number of subjects, the original informal observation, and the statistical results (as well as the unquestionable response in the first trial) in the present more systematic replication, appear

sufficient to make the point. Within 10 minutes after birth, rudimentary directional auditory localization is possible; so is directional oculomotor (perhaps visual?) response. Moreover, at least on a reflex level, a rough coordination between auditory space and visual (motor) space can be observed. This finding is not compatible with the view that space perception, and particularlycross-modal spatial coordination, is based upon a long and arduous learning process (3).

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22 June 1961

Stimulus Generalization of Imprinting

Abstract. Chicks were imprinted with a bluish object, then tested with different spectral values ranging to yellow-green. A systematic decrement in following was related to the stimulus series, although there was considerable generalization to all test values, which increased during testing. These data lead us to question the "irreversibility" of imprinting.

Lorenz (1) was the first to describe imprinting. He wrote of it as an "objectacquiring" process manifested by the behavior of an organism following the "acquired" object. The acquisition of this response occurs early in the life of the organism (typically, domesticated fowl) during a critical period, at which time the animal will follow the first moving object to which it is exposed. For Lorenz, the imprinting process is "irreversible" in that (i) the first object to elicit the following response becomes the only one capable of doing so, and (ii) this acquired behavior is never forgotten.

The first aspect of this "irreversibility" deals with response specificity, implying minimal generalization of the following response to stimuli other than the "acquired object." Moltz (2) points out that there is a lack of adequate research on this. In the relevant studies done by Jaynes (3) and by Hinde, Thorpe, and Vince (4), the training and test objects differed in several physical dimensions, and there was no systematic investigation of generalization with a series of values on a physical continuum.

The purpose of the present research was to investigate stimulus generalization of the following response on the spectral dimension in a manner similar to the study of generalization gradients for other kinds of acquired behavior. This continuum has been used extensively to study generalization of keypecking in the pigeon (see, for example, 5).

Five domestic White Rock chicks were used. These were selected from a larger number; those that failed to imprint to the training stimulus were discarded. All chicks were hatched in the laboratory and raised in individual brooder compartments for the duration of the experiment. The training device was in the form of a circular runway, after Hess (6). The stimulus object was a glass porch globe 6 inches in diameter, which was suspended 2 inches above the floor of the runway and revolved with a 16-inch radius around a central post. The sphere was illuminated internally by a tungsten-filament bulb which was surrounded by a Kodak Wratten gelatin filter also placed inside the globe. Six different filters were used, having dominant wavelength values of 470, 486, 501, 520, 534, and 555 mu. For the human observer, these values range from violetblue to yellowish-green. The brightness of the stimuli were equated for a human observer by using lamps of different filaments and controlling the voltage. Immediately above the globe was a transistor radio speaker which played a tape recording of the experimenter's voice repeating "Come, chick, chick, chick, chick."

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Approximately 16 hours after hatching, each chick was placed in the apparatus next to the globe, illuminated by light of 470-m_{μ} wavelength, and was trained to follow the globe by a procedure analogous to successive approximations. The globe was moved by hand back and forth as the chick followed it around the runway for a 30-min session. On the three subsequent daily training sessions (17 min each), the globe was moved automatically in a timing sequence of 6 sec of movement alternating with 12 sec of rest. The globe traveled around the runway about

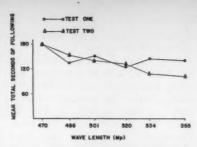


Fig. 1. Mean generalization gradients for subjects imprinted at wavelength 470 m μ .

five times at an approximate speed of 1 inch/sec.

Days 5 and 6 were generalization testing sessions. The chicks were first exposed to the 470-m $_{\mu}$ light for 5 min of further training and then all six stimulus values were presented in a different random order for each bird for 3 min each. Day 6 was the same as day 5 except that the sound was turned off during testing. Following behavior was measured in terms of the number of seconds that the chick was within 1 foot of the sphere.

By the end of training, all subjects consistently followed the stimulus of 470-mu wavelength. The generalization of following to other values on the test days is shown in Fig. 1, where the mean time (in seconds) of following (out of the possible 180 sec) is plotted against the wavelength of the test stimulus. Perfect following was obtained for the training stimulus. A decrement is observed for other values, and, particularly on test 1, this decrement is systematically related to the difference between training and test stimuli. In general, there was more following on test 2, which shows that

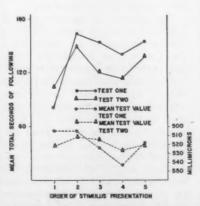


Fig. 2. Mean following scores and mean test stimulus values in order of stimulus presentation, excluding the training value (470-mμ wavelength).

the presence of the sound was not critical in eliciting following during testing. Both parametric and nonparametric analyses of variance (treatments × subjects design) indicated a significant generalization decrement at the .05 level of confidence for the combined data of the 2 days of testing and at the .10 level for the first day alone. The experimeter noted "distress cries" uttered at some time to all testing stimuli except the training value, which typically elicited "contented chirping."

In Fig. 2 the scores for following are analyzed with respect to order of presentation of test stimuli, disregarding stimulus values. The test trials on which the training stimulus presented are omitted here. The lowest scores were obtained on both days during the first test period, after which there is an abrupt increase. There is generally more following on test 2. This increase in the amount of following over time, both within and between test days, indicates a loss of specificity of the following response to the "acquired" object. To determine whether the form of the curves in Fig. 2 is due to the test values randomly assigned to different test periods, the mean test values for each period are also presented. While there is some correspondence between the following scores and the mean test values for periods 2 through 5, the low scores obtained on the first periods are not accompanied by mean test values particularly remote from the training stimulus.

This study demonstrates that imprinting generalizes decrementally on a stimulus continuum. In this way it is similar to many other kinds of acquired behavior, and certainly no more specific. In fact, the obtained gradients are flatter than those obtained for the same continuum for key pecking in the pigeon (5), where the response rate falls to near zero over a similar range of stimulus values. In our case, the gradient appears to flatten out on test 1 at about 60 percent of the score obtained for the training stimulus. It may be, of course, that we have not isolated a crucial characteristic of the stimulus object, and that changes in shape, size, or speed of movement would lead to a greater decrement. On the other hand, it is known (Schaefer and Hess, 7) that neonatal chicks can discriminate among colors. If the "object-acquiring" process was very specific, a steep generalization decrement would be expected for any discriminable aspect of the imprinted stimulus.

The over-all increase during the course of testing presents a difficulty for the assessment of generalization gradients, since this effect is confounded with stimulus difference to flatten the gradient. It would be advisable to use shorter testing periods and to balance test values systematically with regard to order of presentation. But the development of following behavior to other stimuli than the training value supports the evidence from the generalization gradient that leads us to question any extreme specificity of the "object-acquiring" process (8).

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- This report is condensed from an undergraduate honors project submitted by the senior author, who is now at the University of Missouri. It was supported by funds from the Dension University Research Foundation and by grant M-2414 from the National Institutes of Health. We acknowledge the suggestions of James Polt on experimental procedure and the aid of Sheldon Canfield in designing the apparatus.
- 4 August 1961

Identification of Small Animals by Proximity Sensing

Abstract. Individual deer mice are identified by magnetic proximity sensing. Approach of an animal wearing a small ferromagnetic collar unbalances an excited inductance bridge which triggers recording circuitry. In conjunction with conductance proximity sensing, the techniques can identify four individuals. Some results on the tendency of two females to follow one another are cited.

Studies of social interactions among small animals have been hampered by lack of techniques for automatic identification of individuals. Limitations are particularly serious for studies of nocturnal animals. Past work with these has hinged either on laborious direct observation or upon observation of end positions (1). The identification methods described herein depend upon the detection and differentiation of small metal collars by proximity switches. Since we have used ferromagnetic sens-

ing most extensively, it has been selected for detailed illustration.

A general program of our laboratory has been to develop techniques that enable a broad spectrum of behavior of small animals to be monitored automatically for long periods (2). The behavior of a pair of female deer mice, Peromyscus maniculatus, has been studied in detail, first the behavior of each animal individually, and then the behavior of both in consort. Ferromagnetic proximity sensing enabled a large fraction of the combined activity to be assigned to one individual or the other.

The chief prerequisite of an identification station (Fig. 1A) is that the animals must approach to within about 1/4 inch of the sensor face (a in Fig. 1A). The station illustrated penetrates the sidewall (b) of an experimental enclosure and dovetails into the cut-out area of a partition (c) which divides the enclosure into two compartments. Animals are identified during passage between these compartments, one of which contains the nest, and the other an activity wheel and food and water. This single station gives a high degree of individual activity assignment.

The ferromagnetic method utilizes a magnetic proximity sensor (Honeywell #SB84A), the pick-off element of which is a two-pole excited inductance bridge. Near approach of ferromagnetic material reduces the reluctance of the flux paths linking the coils of the bridge, thereby unbalancing it. The resulting signal triggers recording circuitry. Ferromagnetic collars each consist of two open 0.3-g rings of 0.035-inch soft iron wire closed snugly about the animals' necks. Nonferromagnetic dummy collars are made of soft copper wire.

The magnetic proximity sensor (d) comprises a portion of the wall of a circular passageway (e) counterbored into two matched 1/4-inch-thick Plexiglas plates (f). A shutter (g) of 0.045inch stainless steel rotates upon a ball bearing (h) press-fitted into its arm. This bearing fits lightly upon a 1/8-inch shaft (i) through the plates (f). A recess milled into the plates' inner surfaces provides pivoting freedom for the shutter, which occludes all but a semilenticular area of the passageway adjacent to the sensor. To effect passage, the animals simply brush aside the shutter (which gives way easily), necessarily apposing their collars to the sensor face

Self-cutoff circuitry is employed to

reduce any possible disturbance of the animal that might be caused by magnetic attraction of the collar in the field of the sensor coils. Thus, the sensor and amplifier (Honeywell, No. R7107A or R7110A) are not energized until the shutter is lifted, which closes the shutter microswitch (i) by cam action (k). The transistorized amplifier and sensor are armed instantaneously (see Fig. 1B) through the normally open terminal of this microswitch (microswitch No. BZ-RW8435). Upon being triggered, the amplifier disarms itself and the sensor within 35 to 50 msec by negative feedback involving a rocker-arm impulse relay (Potter & Brumfield, No. PC11A). Upon firing of this relay, a first pathway in series with the normally open terminal of the microswitch is opened, with concomitant closing of a second pathway in series with the normally closed terminal. When the shutter closes, after the amplifier relay has been triggered, a potential is applied through the normally closed terminal of the microswitch (in series with the now closed second pathway) to the coil of the impulse relay. Refiring of this relay reestablishes the normal series pathways. Thus, field effects are limited to a small fraction of a second, which turns out to be negligible in practice.

Each opening of the shutter is recorded by one channel of an Esterline-Angus 20-channel event recorder and counted by a parallel Veeder-Root magnetic counter. Each triggering of the sensor is recorded on an adjacent channel and counted on a second counter (Fig. 1C). Thus, scoring of a passage by both channels and counters identifies the animal with the ferromagnetic collar; scoring by only one channel and counter identifies the other occupant. Passages are sufficiently frequent that strip-chart recording without auxiliary digital printout should be at a chart speed of not less than 1 foot per

An illustrative record of passages of two mature female deer mice between enclosure compartments is reconstructed in Fig. 1C. As an example of information obtained by using this identification technique, some findings on the tendency of these animals to follow one another to and from the nest are cited.

During a 1-week period, animal A (iron collar) entered the empty nest 60 times; animal B (copper collar), 189 times; unidentified, 14 times. In the same period, A left the nest when both

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I음 E-A (G) IIO Vac Channel Two Channel Three 6, V-R (G) Rocker-Arm **Amplifier** Counter Two Relay Impulse Relay (N)1c 1h V-R (G) H(N) (N)H (N)4 Counter Three Shutter 0 $(0)_{5}$ 3(0) $(0)_{6}$ Microswitch **Amplifier** Coil $(0)_1$)-Input -(G) Channel No.7 11 1 13 6:00 6:10 5:50 p.m.

were present 41 times; B, 54 times; unidentified, 32 times. Animal B followed animal A into the nest on 50 percent of A's identified entrances, whereas A followed B on only 3.2 percent of B's identified entrances. Similarly, B followed A out of the nest on 61 percent of A's exits, whereas A followed B on only 14.7 percent of B's exits.

The great majority of followings occurred within 3 min. On only 11 of a total of 81 occasions when one animal followed the other did it wait longer than 10 min before following. Since failure of animal X to follow is defined by the return of animal Y to the original location while animal X is still present, many failures to follow simply reflect prompt returns.

B made many short trips to the nest, whereas A visited the nest much less frequently and, in fact, monopolized the running wheel during active periods. It was clear from these and other results that animal A "dominated" animal B. B was prone to follow A, whether into or out of the nest or running wheel or through the passage (see Fig. 1C), whereas animal A followed animal B infrequently.

The basic wiring diagram for the ferromagnetic sensor is coded on a computer-type programing panel (Fig. 1B). Relay modules and other components plug interchangeably into the rear of the panel. The use of such panels allows

Fig. 1. (A) Schematic scale drawing of identification station. See text for explana-(B) Wiring diagram tion of letters. of ferromagnetic sensing circuitry on computer-type panel. Circles represent bananajack outlets; letters within circles identify functions or connections; letters to the side, connections only. Abbreviations: H, hot terminal of 110-volt a-c source; G, neutral terminal of 110-volt a-c source; N, neutral or common relay or switch terminal; C, normally closed terminal; O, normally open terminal. Connect all banana jacks marked H or G with H or G, respectively, of 110-volt a-c source. Connect pairs of identically numbered banana jacks to one another. Jacks numbered with subscripts need be connected only with jacks identically numbered (C) without subscript. Angus record of passages of two female deer mice during a 1/2-hour period. Channel 1, presence in compartment containing the nest; channel 2, signals from ferromagnetic sensor; channel 3, signals from shutter microswitch; channel 4, presence in compartment containing the wheel. Arrows on signal marks indicate direction of movement. On the two occasions when animal B (channel 3) followed closely after animal A (channels 2 and 3), the actual interval was only a few seconds.

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great flexibility, and the illustration and practice of wiring are greatly simplified.

Three individuals can also be identified by using ferromagnetic sensing. The soft-iron collar of the third animal should weigh about 1 g. The excitation voltage to the sensor bridge is made reducible with a normally shorted series resistor, so that when it is in series, the amplified just fails to respond to the signal generated by the presence of the 0.6-g collar. Triggering of the normally wired amplifier by either collar now open-circuits the short and also establishes a pathway to a third recording channel. With the short open-circuited, only the presence of the heavy collar can trigger the amplifier. Thus, scoring of a passage by all three channels identifies the animal with the heavy collar; scoring by only two channels identifies the animal with the light collar; while scoring by only one channel identifies the third animal.

For identification of a fourth animal, conductance proximity sensing is employed in conjunction with the ferromagnetic method (see Fig. 1A). We have used the Bently D-151 detector (3), which is essentially an eddy current sensor. The head (l in Fig. 1A) of this unit contains a pancake-wound coil pick-off element which is loaded by the near approach of any conducting material (which appears to it as a shorted secondary coil). Loading of the pancake coil generates a change in the radiofrequency output of a regenerative radio-frequency oscillator (modified Colpitt configuration). The d-c envelope of this output is either monitored directly or converted to a digital signal by a "Schmidt trigger" binary switch. The collar of the fourth animal can be of any conducting nonferromagnetic material, but the dummy collar must then be nonconducting (4).

Note added in proof. It has come to my attention that T. Royama used magnetic proximity sensing in a nest recorder to differentiate between the visits of a male and a metal-banded female great tit, Parus major [Brit. Birds 52, 295 (1959)1.

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 This research was supported by grant No. G14533 from the National Science Foundation. 15 August 1961

Taxonomic Status of the Pygmy Marmoset (Callithrix pygmaea Spix)

In an earlier issue of Science (1) there appeared a report on the pygmy marmoset as an experimental animal. Because it is possible that this species may become an established laboratory animal, it appears essential that its taxonomic status be correctly deter-

Callithrix pygmaea Spix is a form of the group of marmosets of which the brush-eared marmoset known as Callithrix jacchus Linnaeus is typical and of which it is the westernmost representative. This is a true pygmy. It does not deserve generic or even subgeneric rank. The original specimen (2) was collected by the German zoologist J. B. von Spix at Tabatinga (now Sapurara) on the north bank of the Amazon River on the Brazilian side of the Brazil-Colombian border, about 250 miles down river from Iquitos in the province of Loreto, Peru, from which area the stock now kept at Los Angeles was derived. It also occurs in the forested area on both sides of the upper Amazon and is known to be common in the area of the Napo, Copataza, and Pastaza rivers in northern Peru and the Oriente Province of Ecuador and along the lower Ucayali River, being on record eastward in Brazil at least as far as the Juruá River (Eirunepé, formerly João Pessoa). The type locality of Lönnberg's niveiventris (3) is very slightly further east, in the area of the mouth of the Teffé River (Lago de Ipesuna). There is no doubt that this is not different from the original pygmaea and that niveiventris is not a valid name. The Los Angeles material comes from an area clearly within the range of the original pygmaea, west, not east, of the type locality.

These conclusions have been recently confirmed by examination of a series of specimens from localities covering the whole area of distribution of this form, at the British Museum (Natural History), London, England.

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- 24 July 1961

Carotid and Vagal Afferents and **Drug Action on Transcallosally Evoked Cortical Potentials**

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Abstract. The use of transcallosally evoked cortical potentials to study the action of intracarotidly injected drugs on cerebral synapses has necessitated the demonstration that vagal, baroreceptor, and chemoreceptor influences do not play essential roles in the drug effects observed -for example, the cerebral synaptic inhibitory action of serotonin.

Transcallosally evoked cortical potentials have proved to be very useful tools in studying the effects of drugs on cerebral synaptic function (1). In order to obtain central effects with little complication from peripheral ones the drugs have been administered by close arterial injection (injected "intracarotidly"), because this achieves adequate concentration in the ipsilateral hemisphere and the subsequent dilution in systemic blood ordinarily lowers the concentration to a subthreshold level for peripheral effects. Afferent inflow has been reduced by light anesthesia, or curarization (2) has been used to eliminate proprioceptive inflow. Since such isolation from the periphery is incomplete, we needed to examine the influence of persisting afferent inflows, such as inflows over cranial nerves, as in the case of the vagus; and, especially because of the comparatively high concentration of drugs bathing the carotid sinus and carotid body due to the intracarotid route of administration, we needed to examine the possibility of baroreceptor and chemoreceptor influences on the transcallosally evoked potentials.

Section of the vagus nerve in the neck, surprisingly, impaired the ability of serotonin to reduce the transcallosally evoked cortical potentials, but, as seen in cat experiments (Fig. 1), this was a temporary, reversible effect. It developed that actual section of the vagus nerve was not necessary, but that a crush would elicit the same temporary hindrance of cerebral serotonin action. Since recovery could be accelerated by subsequent application of cocaine to the cut end or to the crushed region (Fig. 1), and since prior application of cocaine prevented occurrence of the phenomenon, it is concluded that the interference with cerebral serotonin action by vagus section or crush does not imply dependence of serotonin's cerebral synaptic inhibitory

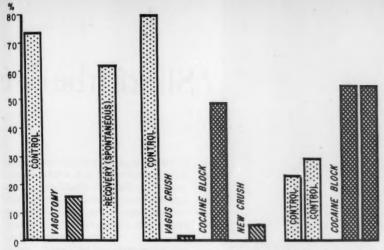


Fig. 1. Influence of vagal afferents on cerebral synaptic inhibition by serotonin.

action on intact vagi, but implies simply that the cut or crush initiates. a strong enough volley of afferent impulses to complicate and obscure the central effects of serotonin.

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In Fig. 1, the bar marked "control" indicates the percentage of inhibition by serotonin before section or crush. Spontaneous recovery ("healing of the killed end" or sealing off of the irritated region) occurred in about 90 minutes, while cocaine-induced recovery took place in about 5 minutes. The new crush, after cocaine, was applied to a fresh section of the vagus, central to the site of previous cocainization. That the influence of vagal afferents is an underlying aspect of the situation and that spontaneous vagal afferent impulses can modify the effect studied is illustrated by the group of bars at the right of Fig. 1. These show that, in an experiment in which serotonin effects were relatively small in two consecutive trials, cocaine block of the otherwise untouched vagus enhanced the serotonin action. Presumably there had been sufficient afferent inflow in the undisturbed vagus to partially offset the serotonin action, whose full effect was released by blocking the vagal inflow with cocaine.

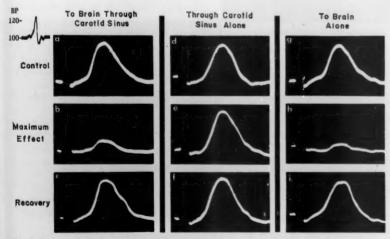


Fig. 2. Nonparticipation of carotid sinus in serotonin (10 μg/kg) inhibition of transcallosally evoked cortical potentials in a pentobarbitalized cat.

The possibility that intracarotid serotonin modulates baro- and chemoreceptor control, originating in the carotid sinus (3) and carotid body. thereby modulating the cortical potential, also required examination. First it was demonstrated that denervation of the carotid sinus, unilateral or bilateral, did not alter the cerebral synaptic inhibitory action of serotonin in these experiments. Secondly, it was shown (Fig. 2) that the cerebral synaptic inhibitory action of serotonin was not significantly altered when the carotid sinus and carotid body region were bypassed by injecting the serotonin cephalad to this region (compare a, b, c with g, h, i). Repeating the injection but allowing the serotonin to perfuse the carotid sinus and carotid body region alone, without access to the brain, had no effect on the evoked potential (d. e. f). Carotid reactivity is evidenced by the rise in blood pressure (Fig. 2, top left) that is induced by occlusion of the common carotid arteries below the sinuses.

These experiments indicate that in the lightly anesthetized cat the transcallosally evoked potential is still modifiable by afferent inflows, especially when they are as great as that initiated by trauma to the vagus nerve, but that the intracarotid administration of the doses of serotonin used does not produce baro- or chemoreceptor influences sufficient to modify the cerebral synaptic inhibition demonstrated by reduction in the height of transcallosally evoked cortical potentials. Completely isolated transcallosal and corticocortical preparations are under study (4).

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The state of science, as unrolled on the giant screen of the AAAS annual meeting in Denver, should be a first-rate reference for that favorite of science fiction: a more highly developed intelligence elsewhere in the galaxy, tuning in occasionally to decide whether contact across the light years seems either possible or desirable.

The celestial observer would note some sharp differences between this and the first mile-high meeting more than a half century ago, when 311 scientists gathered in a Denver high school auditorium to review such matters as the geology of ore deposits and the phylogenetic relations of vertebrates. In the 1961 array of over 300 scientific sessions scheduled to occupy most of the public meeting space in Denver's four largest hotels, at which some 2000 scientists will present 1500 papers, even an advanced intelligence would have a hard time deciding where and how to sample. It would, however, note rather quickly that while part of the giant spectacle still presents the astonishing diversity and mutual irrelevance of ex-

Instruments that can probe 4 billion light years into space and reveal events at the molecular level are disclosing the fundamental patterns of nature and uniting the analytic specialties around a common focus. One example of the many results of the great instruments at Caltech and the Carnegie Institution's Mount Wilson-Palomar laboratories is the photographic record made last year by Rudolph Minkowski of the most distant galaxy so far measured, a cluster 4 billion light years distant and initially located by radio telescope. The photograph above is familiar North American nebula.

Molecule of heredity in Diplococcus pneumoniae is revealed by M.I.T.'s C. E. Hall in the electron micrograph shown here (about × 81,000). The micrograph is part of the evidence for a recent report by Hall and I. F. Cavalieri that DNA in this bacterium occurs as two double helixes as compared to one double helix of the Watson-Crick model. Lying side by side, two double helixes are apparently able to transfer information to adjacent particles.



e Focus: 128th Annual Meeting

hibits in a Victorian museum, some 40 symposia as well as other sessions compose the nub of a developing pattern: these are the forums where the specialists meet to talk across the walls that for a long time have divided their observations.

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But all the wonderfully assorted raw materials of science will be there, too. Scientific observers will report on matters ranging from acquisition of speech in the mynah bird to decision-making, in international political crises, from the private life of a cat to mimicry of honey bees by syrphid flies. In the sessions of the many scientific societies which will join with the annual meeting there will be consideration of the parental drive of fish, management games as instruments for teaching system principles, neuro-endocrine control of mating behavior in cockroaches, women in prison, sleep deprivation in rats, the architecture of the pineal gland, and literally a thousand other things. Not much of this colorful harvest would as yet be pieced together, but, among the bewildering variety, a careful auditor might discern new clues to the "grand recurrences" that science finds in the natural world. And in sessions on the computer and the human brain he might find hope that, as Robert Morison said recently, the "technology of data gathering and processing will help to free us from the burdens of specialization.'

The interdisciplinary symposia, however, will consider, not raw facts, but facts already fabricated into major building blocks of such clarity that half a dozen specialists can at last agree on their dimensions. The new ability of the specialists to talk to each other is in part attributable, as Frank Horsfall has pointed out, to the greatly extended reach of the new instruments of science, most of them the result of a half century of diligent specialization.

When biochemists, geneticists, practicing physicians, immunologists, microbiologists, and biophysicists sit down to examine deoxyribonucleic acid, the material that set off the current revolution in the life sciences, they will all be using the same focus, and the focus will be at the molecular level. When, at this Medical Section symposium on human genetics, R. L. Sinsheimer, for example, describes finding single-strand DNA in a phage of Escherichia coli and goes on to tell what light this new structure gives on the key question of how the master molecule of life duplicates itself, he will be able to show electron micrographs as part of the evidence. When R. Ceppellini of the University of Turin tells how he thinks the nucleotide code of DNA may mold the uniquely specific antibodies that protect each of us, he will be able to draw on a half dozen lines of physicochemical evidence, most of them centering around the forces that shape and break molecular bonds. The new common focus, and to a surprising extent, common language may make it possible for these men to jointly mount a new attack on such unsolved questions as: How do the nucleic acids shape the 700 cellular enzymes known in the human species whose presence or absence is the difference between bodily health and disease? How do adaptive mutations originate?

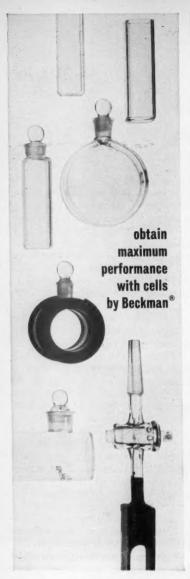
There will probably be echoes of some of these questions at two generalsession symposia on divergent subjects. At the interdisciplinary symposium on the first 5 billion years of geochemical evolution, geochemist Philip Abelson, exploring the influence of primitive environment in shaping the origin of life, may throw some light on whether life began in the random encounter of a giant DNA molecule with a reactive protein. Here astronomer G. R. Burbidge, chemist Harold C. Urey, and geologist Albert Engel will join in exploring the origin of the chemical elements, of the atmosphere of planets, and of the earth's crust.

The DNA molecule will appear again at the interdisciplinary symposium on existing levels of radioactivity. Among

the many sorts of cellular damage that may result from ionizing radiation, mutilation of the genetic template is, of course, the effect that will pass along the cost of current nuclear testing to generations yet unborn. Of those now alive, an unknown fraction may count the cost as DNA damage or a life shortened by cancer. New facts on the latter can be expected from P. R. J. Burch, who will come from the University of Leeds in England to discuss the relationship of existing radiation levels to carcinogenesis.

While an extraterrestrial observer might find in this symposium some indication of whether the human species is likely to survive its own experiments, he would want to check this by reference to the address of Atomic Energy Commissioner Glenn Seaborg, who will report on how one of the two dominant political forces now influencing species survival is running its atomic arsenal. Other indications may come from the special symposium on problems of survival, arranged by the AAAS Committee on Science in the Promotion of Human Welfare and from Bentley Glass's talk on the biology of nuclear war.

If prospects thus surveyed seem less than encouraging, we can shift from the somewhat dreary outlook for our own species to the grand spectacle of continuing evolution on a galactic scale. Mt. Wilson's Halton Arp, who recently showed how to use chemical analysis with new precision in calculating the age of stars, will describe the long evolution of stars and galaxies in a Moving Frontiers of Science lecture. And we will probably want to follow Matthew Stirling 1000 years back in time and into the sacred well of Chichén Itzá, where the Mayas sacrificed the flower of their youth, by means of the annual National Geographic Society lecture and color film. Margaret Mead, presiding, will be there to remind us that the Age of Anxiety is, after all, not a bad trade for the Ages of Terror that preceded it.



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Fullerton, California

Program Summary

Anthropology. (H)

Program chairman: David M. Pendergast, University of Utah, Salt Lake City.

Thursday 28 December

The Concept of Race. Symposium arranged by Jack Kelso, University of Colorado, who will preside. A history of the concept of race, B. M. Alfred. Race as a problem in classification, Donald R. Ackerman and Jack Kelso. Race as a sociological concept, Edward Rose. Race as an evolutionary episode, Frederick S. Hulse. Geographic and microgeographic races, Marshall T. Newman. Review and comments, Walter Weir.

Friday 29 December

Civilizations in Desert Lands. Symposium arranged by Richard B. Woodbury, University of Arizona, who will preside. Evaluations of dry-land environments by societies at different levels of technical competence, Homer Aschmann. Role of natural forces in the ancient Indus Valley and Baluchistan, George F. Bales, Jr. Synopsis of the historical demography and ecology of the Diyala River basin, central Iraq, Robert M. Adams. Social responses to the problems of the distribution of irrigation water, René Millon.

Early Man in the Western United States: Cultural Continuities. Concurrent symposium arranged by Richard D. Daugherty, who will preside. Early man's utilization of the Great Plains environment, Fred Wendorf. An approach to early cultures in northwestern America, Earl Swanson. The Rawlings, Wyoming, mammoth kill, George A. Agogino and Henry and Cynthia Irwin. Early man in British Columbia, Charles Borden. Cultural relationships between the Plateau and the Great Basin, Richard D. Daugherty. The earliest cultures in the western United States, Alex D. Krieger.

The Wetherill Mesa Project. Concurrent symposium arranged by Douglas Osborne, supervisory archeologist, Wetherill Mesa Archeological Project, Mesa Verde National Park, Colorado, who will preside. History, organization, and program of the Wetherill Mesa Archeological Project, Douglas Osborne. Archeological survey of Wetherill Mesa, Alden C. Hayes. Excavation

of Long House, Wetherill Mesa, George S. Cattanach. Excavation of Mug House, Wetherill Mesa, Arthur H. Rohn. Operation of the Wetherill Mesa Laboratory, Richard P. Wheeler. Plant ecological studies on Wetherill Mesa, James Erdman. The environmental measurements program and animal ecological studies, Charles Douglas and Mark Paddock. Palynological studies, Paul S. Martin and William Byers. Dendrochronological studies and sampling, Marvin Stokes and Tom Harlan. Dendrochronological dating of Wetherill Mesa archeological sites, Robert F. Nichols. Soil studies at Wetherill Mesa, Orville Parsons. Agricultural plants of Wetherill Mesa, Hugh Cutler. Nonagricultural plant identification, Stanley Welsh. Trace element studies on Wetherill Mesa fecal material, Bruno Sabels. Mesa Verde surveys, Emma Lou Davis and James Winkler. Oral tradition studies, Keres, Florence Ellis. Oral tradition studies, Tanoan, Mr. and Mrs. Kenneth E. Knudson, Museum studies of early Mesa Verde collections. Carolyn M. Osborne. Physical anthropology of Wetherill Mesa burials, Fred Hulse. Pathology of the Wetherill Mesa burials, James S. Miles, Parasitological studies of Wetherill Mesa fecal material, Robert Samuels. Orthodontic studies of Wetherill Mesa burials, J. M. Mc-Canlies. Petrologic studies of Wetherill Mesa cultural materials, Charles B. Hunt. Entomological studies on Wetherill Mesa, Samuel A. Graham, Animal bones from the Wetherill Mesa excavations, Thomas Mathews. Summary and critique, Richard B. Woodbury, University of Arizona.

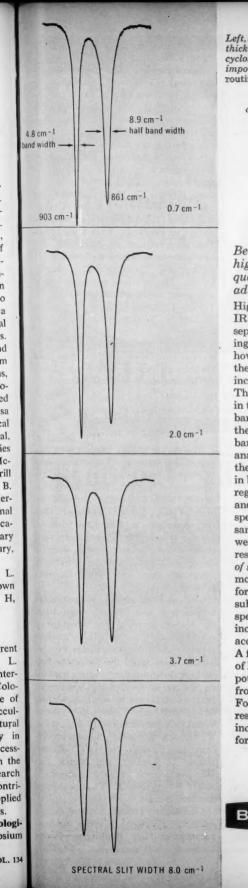
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Anthropologists' Dinner. James L. Giddings, Haffenreffer Museum, Brown University, secretary of Section H, presiding.

Saturday 30 December

Applied Anthropology. Concurrent symposium arranged by Harold L. Amoss, acting director, Office of International Education, University of Colorado, who will preside. Importance of ethno-historic data for studies of acculturation, Omer C. Stewart. Agricultural extension and sociological reality in Brazil, Sydney M. Greenfield. Successful transiency—some findings from the Page, Arizona, community research project, Henry H. Frost. Some contributions of recent research to applied anthropology, Theodore D. Graves.

Role of Animals in Human Ecological Adjustments. Concurrent symposium



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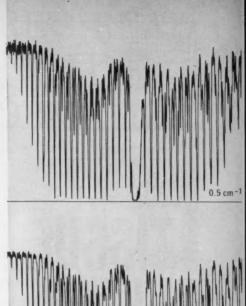
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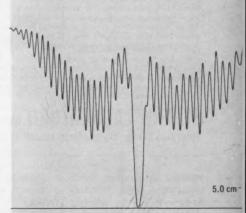
Left, spectrum of a 0.21 mm. thickness sample of spectro-grade cyclohexane demonstrates the importance of high resolution for routine quantitative analysis.

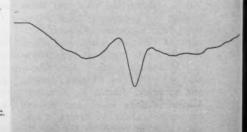
> Right, the C-H stretching band of methane illustrates the increased research data obtainable with high resolution spectroscopy.

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High resolution of the Beckman IR-7 does more than merely separate closely spaced neighboring bands. Note, for instance, how the apparent intensities of the two cyclohexane bands increase with higher resolution. The relatively greater increase in the intensity of the 903 cm⁻¹ band at higher resolutions is the result of its narrower halfband width. These two commonly analyzed samples demonstrate the importance of high resolution in both low and high frequency regions and, for both gas and liquid samples. Comparative spectra were run with identical samples; slit width and resolutions, were varied as noted. A High resolution is essential for all areas of spectroscopy; for studies of molecular motion and structure, for differentiating between substances which exhibit similar spectra, and also for providing increased sensitivity and absolute accuracy for quantitative analysis. A further long-run advantage of high resolution is the increased potential for transferring data from one instrument to another. For more information about high resolution spectrophotometers, including indene spectra, write for Data File 38-47-02







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arranged by Anthony Leeds, research Pan American Union. specialist, Andrew P. Vayda, assistant professor of anthropology, Columbia University, presiding. Introduction, Andrew P. Vayda. Athabaskan horse and sheep herding and contrasting social institutions, Peter Kunstadter. Reindeer herding and Chuckchi social institutions, Anthony Leeds. Pigs, dogs, and children in a Melanesian economy, Anne Chowning. East African livestock, society, and economy, Harold K. Schneider. Llamas in Inca social and political organization, John V. Murra. Camel pastoralism in North Arabia and the minimal camping unit, Louise E. Sweet. Discussion, Homer Aschmann. Conclusion, Andrew P. Vayda.

Incest in Cross-Species Perspective. Concurrent symposium arranged by Margaret Mead, American Museum of Natural History, who will preside. Film: The Private Life of a Cat, by Alexander Hammid. Sex dynamics within kinships of free-ranging wild ungulates, Margaret Altmann. Brother and sister in social structure and fantasy in Zuni, Ruth Bunzel. A hypothesis for the genetic basis of the universality of the incest taboo and its relation to kinship organization, Yehudi Cohen. Grounds for incest, Gregory Bateson. Early adolescent friendship patterns as a con-

structive handling of the incest barrier (film), Rhoda Métraux.

Interdependence of Archeology and Ethnology. Concurrent symposium arranged by Warren L. D'Azevedo, University of Utah, who will preside. The ethno-history of the Eastern Shoshone: a problem in the use of archeological and ethnographic data, Donald D. Fowler. A joint archeological and ethnological approach to the development of southwestern Pueblo social organization, Edward P. Dozier. Archeology and ethno-history in Africa, Creighton Gabel. Trait distribution and archeology in Polynesia, Robert C. Suggs. The interpretation of Paleolithic art: uses and abuses in the methodology of ethnographic comparison, Morton H. Levine. The relations of archeological and ethnological theory, Walter W. Taylor. Discussants: René F. Millon, Richard B. Woodbury, and Jesse D. Jennings.

Section H is a cosponsor of the foursession symposium, Physiological and Biochemical Aspects of Human Genetics, of Section N-Medical Sciences.

Psychology (I)

Friday 29 December

Aspects of Sleep. Symposium arranged by Wilse B. Webb, University of Florida, who will preside. Sleep, environmental control, and timing behavior, Neal M. Burns. Arousal aspects of sleep, Bryce O. Hartman. Current research on sleep and dreams, Chester Pierce. Eye movements and electroencephalograms during sleep in monkeys, Elliott Weitzman. Effects of prolonged sleep deprivation on rats, Wilse B. Webb.

Goals of Psychotherapy—Approaches to Research and Clinical Application. Symposium in two parts. Program of AAAS Section I-Psychology, cosponsored by the Rocky Mountain Psychological Association, the Colorado Psychological Association, and the Colorado Society of Psychologists in Private Practice. Arranged by Alvin R. Mahrer and John R. Thompson, Denver Veterans Administration Hospital. Alvin R. Mahrer, presiding. Speakers: William H. Brown, Victor C. Raimy, Harold D. Locketz, and Morris Parloff. Discussants: Frank J. Rubenstein, Stuart Boyd, John R. Thompson, and Sherman Nelson.

Contributed Papers. Sensory factors related to appetitive behavior and food acceptance. Carl Pfaffmann, Brown University, will preside.



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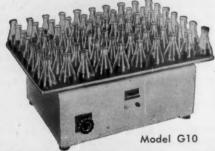
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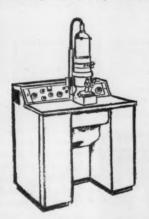
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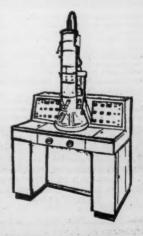
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Saturday 30 December

Sensory Factors in Appetitive Behavior and Food Acceptance. Symposium arranged by Carl Pfaffmann, Brown University. Samuel A. Goldblith, Massachusetts Institute of Technology, will preside. Appetitive behavior and chemoreception in invertebrates, David R. Evans. The organization of hypothalamic feeding areas and the role of gustatory factors, P. J. Morgane. Regulation of intake and magnitude of reinforcement, George Collier. Sensory factors in food acceptance in man, Francis J. Pilgrim. Discussants: John Falk, University of Colorado, and Roland Harper, University of Leeds.

Vice Presidential Address. Frank W. Finger, University of Virginia, secretary of Section I, presiding. Physiological and behavioral studies of the sense of taste, Carl Pfaffmann, Brown University, vice president for Section I-Psychology.

Control of Verbal Behavior. Symposium arranged by Israel Goldiamond, Arizona State University, who will preside. Measurable dimensions of vocal behavior, John A. Starkweather. Experimental shaping of the prosodic features of speech with an autoinstructional device, Harlan Lane. Problems related to the acquisition of speech in the mynah bird, Joseph Grosslight. Control of interview behavior, Joseph D. Matarazzo. Verbal behavior in schizophrenia, Ogden R. Lindsley. Verbal conditioning of formal linguistic structures, Arthur J. Bachrach. Effect of drugs on verbal behavior, Kurt Salzinger, Stephanie Pison, Richard S. Feldman, and Pauline M. Bacon. Self- and experimentercontrol of disrupted and fluent reading behavior, Israel Goldiamond. Interaction between verbal and nonverbal behavior, Ivar Lovaas.

Section I is the cosponsor of the following programs: the two-session symposium of the American Psychiatric Association, Genetics and Evolution in Relation to Human Behavior; three sessions for contributed papers on animal behavior and sociobiology; and the symposium, Evolutionary Changes in the Hormonal and Neural Bases of Reproductive Behavior, jointly sponsored by the American Society of Zoologists and the Ecological Society of America; and a joint symposium with the Cooperative Committee on the Teaching of Science and Mathematics and Section A: Teaching Machines and Mathematics Programs.

Social and Economic Sciences (K)

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Wednesday 27 December

Current Problems in Social-Behavioral Research. Symposium. Program of AAAS Section K-Social and Economic Sciences, cosponsored by the American Statistical Association and the National Institute of Social and Behavioral Science. Arranged by Donald P. Ray, National Institute of Social and Behavioral Science, Washington, D.C. Fitzhugh L. Carmichael, University of Denver and the American Statistical Association, will preside. Vice Presidential Address of Section K. Social statistics and the prediction of human behavior, Frederick F. Stephan, Some notes on sociology in the U.S.S.R., Robert K. Merton, Political science: pure or applied? Duncan MacRae, Jr.

Section K is a cosponsor of the Interdisciplinary Symposium in the Social Sciences: Water and Climate.

American Economic Association

Tuesday 26 December

The Economics of Knowledge and Information. Program of the American Economic Association, cosponsored by AAAS Section K-Social and Economic Sciences. Arranged by Kenneth E. Boulding, University of Michigan. Leslie Fishman, University of Colorado, will preside. Knowledge as a commodity, Kenneth E. Boulding. The productivity and efficiency of investment in education, Fritz Machlup, Information input overload: features of growth in communications-oriented institutions, Richard L. Meier.

American Political Science Association

Wednesday 27 December

Relations. International Invited papers. Program of the American Political Science Association, cosponsored by Section K-Social and Economic Sciences. Arranged by Josef Korbel, Social Science Foundation, University of Denver, who will preside. Soviet policy in the United Nations toward the underdeveloped countries, Richard Rosser. Commentator: Joe R. Wilkinson. Decision-making in international political crises, James A. Robinson. Commentator: George Codding, Jr.

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American Society of Criminology

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Friday 29 December

Annual Business Meeting of the Society.

Annual Awards and Memorial Meeting. Donal E. J. MacNamara, dean, New York Institute of Criminology, and president, American Society of Criminology, chairman. Presentation of the annual award for 1961. Address, Orlando W. Wilson, superintendent of police, Chicago, Ill. Presentation of the August Vollmer Award for 1961. Address: Pathways to improved sentencing, Sheldon Glueck, professor of criminology, Harvard University Law School.

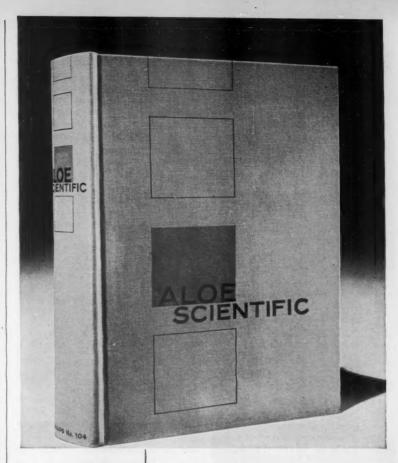
28 and 29 December

Crime, Police, and Prison Problems in Contemporary Society. A four-session program of the American Society of Criminology cosponsored by the American League to Abolish Capital Punishment, New York Institute of Criminology, and the American Academy of Criminalistics.

Rural Crime Control. Symposium arranged by Gordon H. Barker, chairman, department of sociology, University of Colorado, and vice president, American Society of Criminology. Gordon H. Barker, chairman. Crime and delinquency in rural areas-the difficulties and possibilities of legislation, H. Ted Rubin. Problems in the police control of rural crime, Vernon Hastings, Jr. Examples of Indian criminality, Omer C. Stewart. Problems of judges and prosecutors in rural areas. Charles J. Simon. Crime among minorities in rural areas, W. Thomas Adams. Evaluation, Clyde Vedder.

Problems in Contemporary Penology. James M. Reinhardt, professor of criminology, University of Nebraska, chairman. Discussion leader: C. R. Jeffery. Women in prison, Isabel Gauper. The pre-sentence investigation, Leslie C. Reed. The warden's obligations to prisoners from rural areas, Maurice Sigler. Underworld, conventional, and ideological crimes: three points on a continuum of rejection, tolerance, rejection, Ruth Shonle Cavan. Men in prison, Harry C. Tinsley. Observations on narcotics addiction in Hong Kong, Albert Hess.

Research and Experimentation in Criminology. Marcel Frym, University of Southern California, chairman. Discussion leader: Charles Newman. Toward improving the identification of young delinquents, Eleanor T. Glueck.



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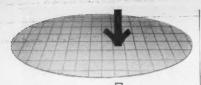
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Predicting criminal behavior, Alfred C. Schnur. The reinforcement theory and criminal behavior, C. R. Jeffery. Delinquency and mental inferiority. Clara Chassell Cooper. Increases in crimes in the underdeveloped countries, Walter Lunden. Delinquent behavior in currently respectable adult males, Sophia M. Robison. Methodological problems in measuring delinquency, M. E. Wolfgang.

Controversies Problems and Twentieth-Century Policing. John P. Kennedy, police commissioner, Los Angeles, California, chairman. Discussion leader: Anthon S. Cannon, University of Utah. State standards for local police recruitment, training, and promotion, G. D. Gourley. Role of the police periodical, Lee Lawder. The case against police juvenile bureaus, August Flath. A philosophy of police management training, Ray Galvin. Value conflicts in law enforcement, Jacob Chwast.

American Sociological Association

Friday 29 December

Sociology of Medicine: Problems and Prospects. Symposium. Program of the American Sociological Association, cosponsored by AAAS Section K-Social and Economic Sciences. Arranged by Conrad Taeuber, Bureau of the Census, Washington, D.C. Ozzie G. Simmons, University of Colorado, will preside. Biosocial aspects of disease, Edmund H. Volkart. The relationship of research methodology to problems in the health fields, Odin W. Anderson. Helping medicine fulfill its social functions, Cecil G. Sheps. The place of the sciences of administration in medical care, Nicholas J. Demerath.

American Statistical Association

Friday 29 December

Problems of the American Highway Operation. Symposium. Program of the American Statistical Association, cosponsored by AAAS Section K-Social and Economic Sciences, and the Biometric Society, WNAR. Arranged by the Colorado-Wyoming Chapter of the American Statistical Association. Edward C. Bryant, Westat Research Analysts, Tempe, Arizona, will preside. Statistical design and analysis at the AASHO road test, Paul E. Irick. Problems of national highway allocation study, G. P. St. Clair. Economic prob-

Program notes for some sections have appeared in previous issues of Science: "Chemistry" and "Mathematics and Related Programs," 27 October, page 1376; "Physics" and "Astronomy," 3 November, page 1438; "Agriculture" and "Geology and Geography," 10 November, page 1534: and "Zoological Sciences." "Botanical Sciences," "Medical Sciences," "Dentistry," and "Pharmacy," 17 November, page 1630.

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On page 1710 of this issue appears a coupon which readers can mail in to obtain a complete program of the annual meeting.

lems of the national highway program, Richard M. Zettel. Problems in costing highway service, Clifton M. Grubbs. Critique and discussion, R. E. Living-

Saturday 30 December

Government Price Statistics. Program of the American Statistical Association, cosponsored by AAAS Section K-Social and Economic Sciences and the Biometric Society, WNAR. Arranged by James A. Niederjohn, Ideal Cement Company, Denver; president, Colorado-Wyoming Chapter, American Statistical Association. Donald Bentley, Colorado State University, will preside. Significance of urban retail structure for price and welfare indexes, Leland L. Howell. Welfare versus market-basket price indexes, Leslie Fishman.

The ASA is also a cosponsor of the program of the Biometric Society, WNAR.

Institute of Management Sciences

Friday 29 December

Management Science. Symposium. Joint program of the Institute of Management Sciences and AAAS Sections P-Industrial Science and A-Mathematics. Arranged by Merrill M. Flood, Mental Health Research Institute, University of Michigan. James R. Jackson, Western Management Science Institute, Graduate School of Business Administration, University of California, Los Angeles, will preside. New analytical methods in management science, Robert R. Singleton. Econometrics and statistics in management science, Satya S.

La.)

Sengupta. Recent mathematical developments of importance in management science, George B. Dantzig.

The Institute of Management Sciences is a cosponsor of the program of the Philosophy of Science Association: Law, Science and Decision Making.

Metric Association

Thursday 28 December

Business Meeting. Arranged by Robert P. Fischelis, president elect, Metric Association.

National Institute of Social and **Behavioral Science**

The National Institute of Social and Behavioral Science is a cosponsor of Section K's symposium, Current Problems in Social Behavioral Research.

Forthcoming Events

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December

6-8. Electrical Furnace Steel Conf., 19th, American Inst. of Mining, Metallurgical and Petroleum Engineers, Pitts-burgh, Pa. (Scientific Liaison Office, Natl. Research Council, Sussex Dr., Ottawa, Canada)

6-8. Latin-American Congr. of Pathological Anatomy, 3rd, Medellín, Colombia. (A. C. Henao, Laboratorio de Anatomía Patológica, Rua Botucatu 720, São Paulo, Brazil)

6-8. National Institutes of Health Symp. on Neuroendocrinology, Miami, Fla. (A V. Nalbandov, 102 Animal Genetics, Univ. of Illinois, Urbana)

6-12. American Acad. of Optometry, Chicago, Ill. (C. C. Koch, 1506-08 Fo-shay Tower, Minneapolis 2, Minn.)

6-16. Food and Agriculture Organization of the U.N. World Health Organization, Nutrition Conf. for the Far East, 5th, Hyderabad, India. (Intern. Agency Liaison Branch, Office of Director General, FAO, Viale delle Terme di Caracalla, Rome, Italy)

6-16. Food and Agriculture Organization of the U.N., Far East Meeting on Animal Production and Health, 3rd, Bangkok, Thailand. (Intern. Agency Liaison Branch, Office of Director General, FAO, Viale delle Terme di Caracalla, Rome, Italy)

7-8. Symposium on Sintered High-Temperature Oxidation-Resistant Materials, London, England. (S. C. Guilan, Powder Metallurgy Joint Group, Inst. of Metals, 17 Belgrave Sq., London)

7-9. American Chemical Soc. Southwest-Southeast regional meeting, New Orleans, La. (P. D. Accardo, California Chemical Co., Oronite Div., Belle Chasse,

7-9. New York Acad. of Sciences Conf.

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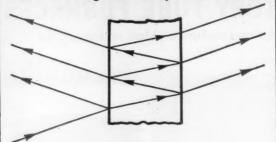
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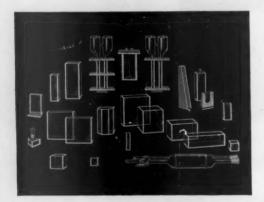
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on the Cervix, New York, N.Y. (W. R. Lang, Jefferson Medical College, Philadelphia, Pa.)

7-9. Texas Acad. of Science, Galveston. (D. E. Edmondson, Mathematics Dept., 115 Bendect Hall, Univ. of Texas, Austin 12)

8. Food and Agriculture Organization of the U.N., Advisory Group on Training in Home Economics and Social Work, Rome, Italy. (Intern. Agency Liaison Branch, Office of Director General, FAO, Viale delle Terme di Caracalla, Rome)

8-9. American Rheumatism Assoc., interim session, Washington, D.C. (F. E. Demartini, 622 W. 168 St., New York 32)

8-9. Association for Research in Nervous and Mental Diseases, annual, New York, N.Y. (Scientific Liaison Office, Natl. Research Council, Sussex Dr., Ottawa,

8-9. Symposium on Plasma Membrane, New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19)

8-10. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park W., New York 23)

9-10. Academy of Psychoanalysis, New York, N.Y. (J. H. Merin, 125 E. 65 St., New York 21)

10-13. American Phytopathological Soc., Biloxi, Miss. (G. A. Zentmyer, Dept. of Plant Pathology, Univ. of California, Riverside)

10-14. Psychosomatic Medicine Symp., 6th, Philadelphia, Pa. (Miss M. R. Carmosin, Hahnemann Medical College and Hospital, 235 N. 15 St., Philadelphia 2,

10-17. Latin American Congr. on Microbiology, 2nd, San José, Costa Rica. (J. L. De Abate, Secretary General, Apartado 1404, San José)

11. Society of Photographic Scientists and Engineers, Washington, D.C. (C. M. Bailey, Rte. 4, Box 404, Fairfax, Va.)

11-15. Agricultural and Public Health Aspects of Radioactive Contamination in Normal and Emergency Situations, technical seminar, The Hague, Netherlands. (Food and Agriculture Organization of the U.N., Intern. Agency Liaison Branch, Office of the Director General, Viale delle Terme di Caracalla, Rome, Italy)

11-15. Symposium on Organization of Agricultural Research, Muguga, Kenya. (Commission for Technical Cooperation in Africa South of the Sahara, Pvt. Mail Bag 2359, Lagos, Nigeria)

11-16. Ionospheric Soundings in the Intern. Geophysical Year/Intern. Geophysical Cooperation-1959 Symp., Nice, France. A. H. Shapley, URSI World-Wide Soundings Commission, Central Radio Propagation Laboratory, Natl. Bureau of Standards, Boulder, Colo.)

12-14. Association for Computing Machinery, eastern joint computer conf., Washington, D.C. (B. Oldfield, I.B.M. Corp., 326 E. Montgomery, Rockville, Md.)

12-15. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, ASAE, 420 Main St., St. Joseph, Mich.)

13. American Acad. of Arts and Sciences, Brookline, Mass. (J. L. Oncley, 280 Newton St., Brookline 46)
15-16. Oklahoma Acad. of Science,

Stillwater. (D. Buck, Northern Oklahoma Junior College, Tonkawa)

17-18. International Congr. of Comparative Pathology, 9th, Paris, France. (L. Grollet, Comité International Permanent des Congrès de Pathologie Compareé, 63 Avenue de Villiers, Paris 17°)

19-23. Inter-American Congr. of Psychology, 7th, Monterrey, Mexico. (G. M. Gilbert, Psychology Dept., Long Island Univ., Brooklyn 1, N.Y.)

22-29. Plant Tissue and Organ Culture, intern. symp., New Delhi, India. (P. Maheshwari, Univ. of Delhi, Delhi)

26-28. History of Science Soc., annual, Washington, D.C. (J. C. Greene, 1121 Iowa Ave., Ames, Iowa)

26-31. American Assoc, for the Advancement of Science, annual, Denver, Colo. (R. L. Taylor, AAAS, 1515 Massa-chusetts Ave., NW, Washington 5)

27-29. American Folklore Soc., Cincinnati, Ohio. (T. P. Coffin, 110 Bennett Hall, Univ. of Pennsylvania, Philadelphia 4)

27-29. American Geophysical Union. 1st Western natl., Los Angeles, Calif. (A. N. Sayre, U.S. Geological Survey, Washington 25)

27-29. American Economic New York, N.Y. (J. W. Bell, AEA, Northwestern Univ., Evanston, Ill.)

27-29. American Physical Soc., Los Angeles, Calif. (K. K. Darrow, 538 W. 120 St., New York 27)

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Program Content

- 1. The two-session AAAS General Sessions, "Moving Frontiers of Science," Part I-Speakers: Howard A. Meyerhoff and Arthur R. von Hippel; Harrison Brown, presiding. Part II-Speakers: Halton C. Arp and E. W. Fager; Harrison Brown, presiding.
- The 29th John Wesley Powell Memorial Lecture. Speaker: Glenn T. Seaborg; Paul M. Gross, presiding.
- 3. On "AAAS Day," the four broad, interdisciplinary symposia—Physics of the Upper Atmosphere; Geochemical Evolution—The First Five Billion Years; Existing Levels of Radioactivity in Man and His Environment; and Water and Climate-arranged by AAAS Sections jointly.
- 4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Harrison Brown; the Tau Beta Phi Address by John A. Logan; National Geographic Society Illustrated Lecture; and the second George Sarton Memorial Lecture by Joseph Kaplan.
- 5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
- 6. The programs of the national meetings of the American Astronomical Society, American Society of Crimi-nology, American Nature Study Society, American Society of Naturalists, American Society of Zoologists,

- Beta Beta Biological Society, Biometric Society (WNAR), National Association of Biology Teachers, Scientific Research Society of America, Society for General Systems Research, Society of Protozoologists, Society of Systematic Zoology, and the Society of the Sigma Xi.
- The multi-sessioned special programs of the American Astronautical Society (Hugh L. Dryden as dinner speaker), American Physiological Society, American Psychiatric Association, Association of American Geographers, Ecological Society of America, National Science Teachers Association, National Speleological Society—and still others, a total of some 70 to 80 participating organizations.
- 8. The sessions of the Academy Conference, the Conference on Scientific Communication, and the Conference on Scientific Manpower.
- 9. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, of the AAAS Committee on Science in the Promotion of Human
- 10. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
- 11. Exhibitors in the 1961 Annual Exposition of Science and Industry and descriptions of their exhibits.

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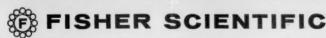
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Temperature-Compensated for Unsurpassed Accuracy: The AO TS Meter provides automatic temperature compensation for all aqueous solutions. Differences in room, instrument or sample temperatures do not affect readings. Error from these sources is reduced to less than 0.1% over the range of 65° to 95°F. Readings are consistently obtained with a degree of accu-

racy, speed and reproducibility significantly better than those obtained with urinometers, the falling-drop method or with instruments uncompensated for temperature.

Direct Readings: You make an immediate analysis directly from the built-in scale . . . without references to graphs, tables or thermometer readings. Two models are available. Model 10400 provides determinations of total solids in plasma or serum and urine specific gravity; model 10401 gives readings of protein concentration and refractive index.

*Total Solids Meter. The AO TS Meter and this method of analysis was developed in close cooperation with Dr. A. V. Wolf, Head of the Department of Physiology, University of Illinois, College of Medicine, Chicago, Ill.

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